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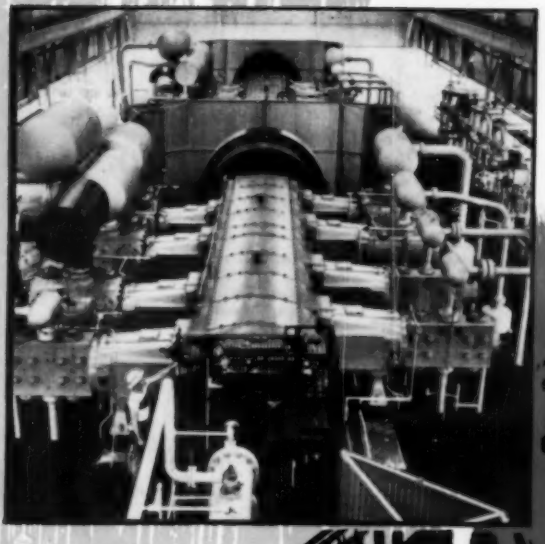
at Calvert City . . . page 63

MAY 1960



Low temperature plants...

their safe operation

...page 37

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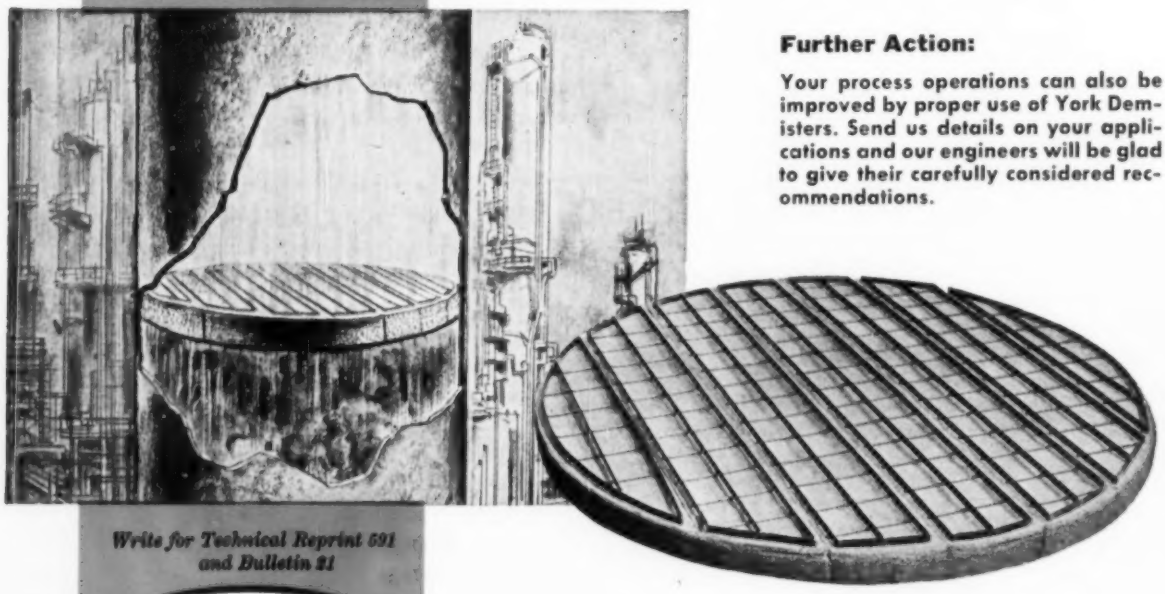

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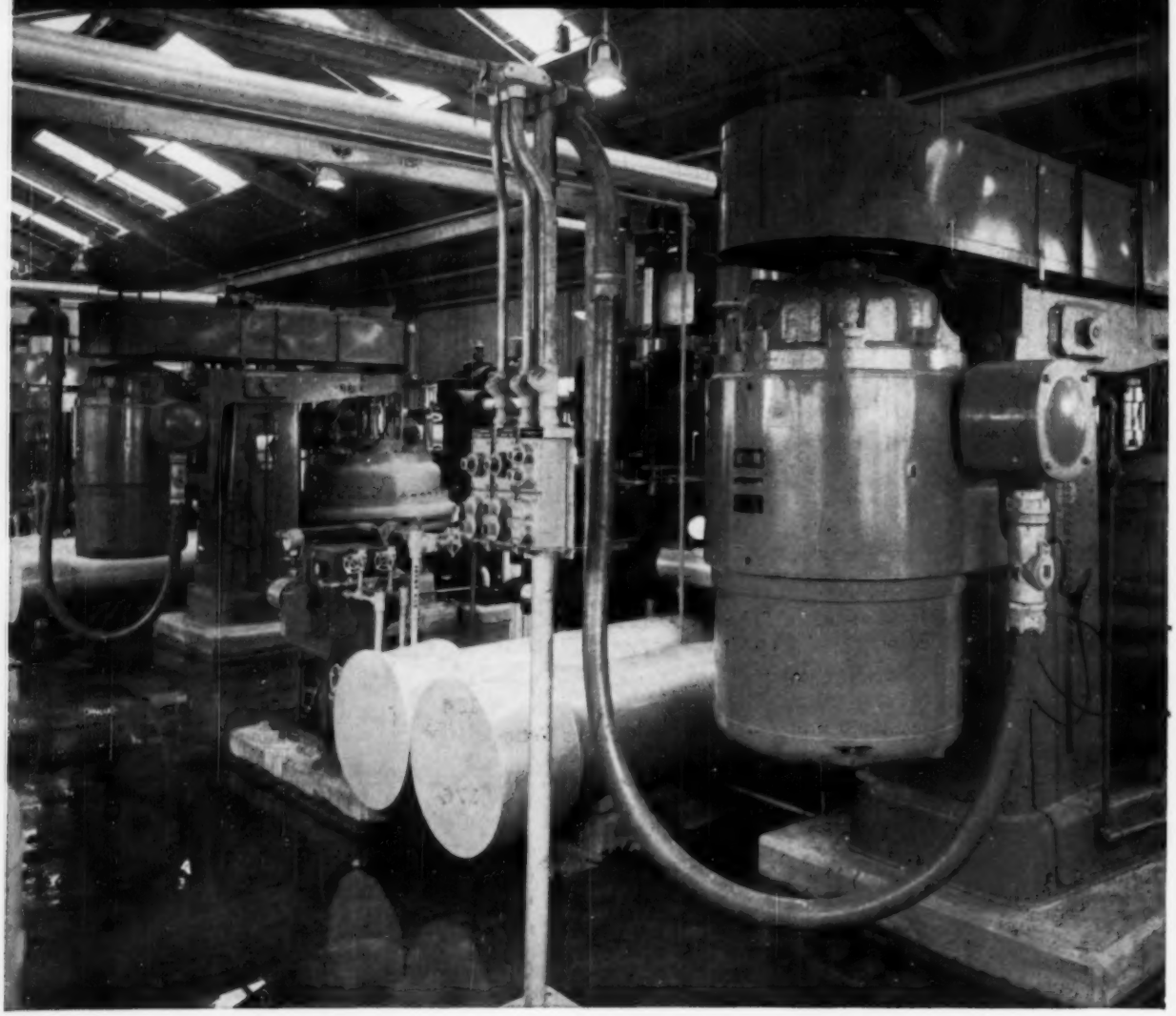

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book reviews

Plant design, chemical kinetics, featured in new books

CHEMICAL ENGINEERING PLANT DESIGN, Frank C. Vilbrandt, and Charles E. Dryden, Fourth Edition, McGraw-Hill Book Company Inc., New York, N. Y. (1959), 534 p., $12.00.

The finest compliment a reviewer can pay an author is to wish that he had written the author's book. This was the first reaction upon reading Vilbrandt's and Dryden's *Chemical Engineering Plant Design*. In this fourth edition, Dr. Dryden has collaborated with Dr. Vilbrandt who was the sole author of the first three editions. In the reviewer's opinion, this new edition represents a significant improvement over the earlier ones. The text throughout unfolds smoothly in a logical development. Quoting from the Preface: "This book presents an analysis of the fundamental principles and factors that are involved in the development of a technically and economically efficient plant process from the laboratory stage through the pilot plant stages to the commercial size unit". In this, the book succeeds very well indeed.

In Chapter 1 an Introduction presents some broad aspects of plant design, a sort of preview of what is to follow. Chapter 2 treats important topics in the development of a project, again in broad strokes. Process design is considered in Chapter 3, which instructs by use of a fairly elaborate example of a design project, including a discussion of process and instrumentation flow sheets. The next logical step, the selection of process equipment and materials, is the subject of Chapter 4. Following an excellent discussion of selection factors, there is an extensive example of an equipment specification job. As one might expect, the next subject is that of plant layout in Chapter 5. While this is a short chapter, the use of templates for 2-dimensional and of scale models for 3-dimensional representation is described. Chapter 6 considers the economic evaluation of the project. Some discussion of cost estimation methods is presented, but the meat of this chapter is the large group of graphs of installed cost of equipment, with the ENR Index appended. The location of the chemical plant and governing factors are discussed in Chapter 7, which includes a useful check list. Having located the plant, the authors proceed, in Chapter 8, to set forth preparation of the plant site and consideration of various plant structures. Chapter 9, labelled Process Auxiliaries, deals largely with piping systems, with shorter sections on process control and power systems. To meet the demand of the burgeoning nuclear age, a substantial chapter entitled Nuclear Chemical Plant Design is included. While the treatment of this subject must of necessity be brief, nonetheless it will give the student engineer some idea of what is involved in nuclear design problems.

Numerous references throughout the book, capped by a list of additional selected references, are a valuable feature. For the teacher of plant design, important suggestions regarding design project procedures are found in the Appendix. There is also an extensive list of letter symbols for chemical engineering. Format and typography are up to the publisher's usual high standards.

This book is heartily recommended to the teacher and student in chemical plant design. It should be on the bookshelf of practicing chemical engineers to round out their storehouse of information, and is strongly recommended to administrative personnel so they can see just what problems confront the engineer charged with the design of a plant.

Reviewed by Dr. R. F. Heckman, Professor of Chemical Engineering and Head of the Department, South Dakota School of Mines and Technology, Rapid City, South Dakota.

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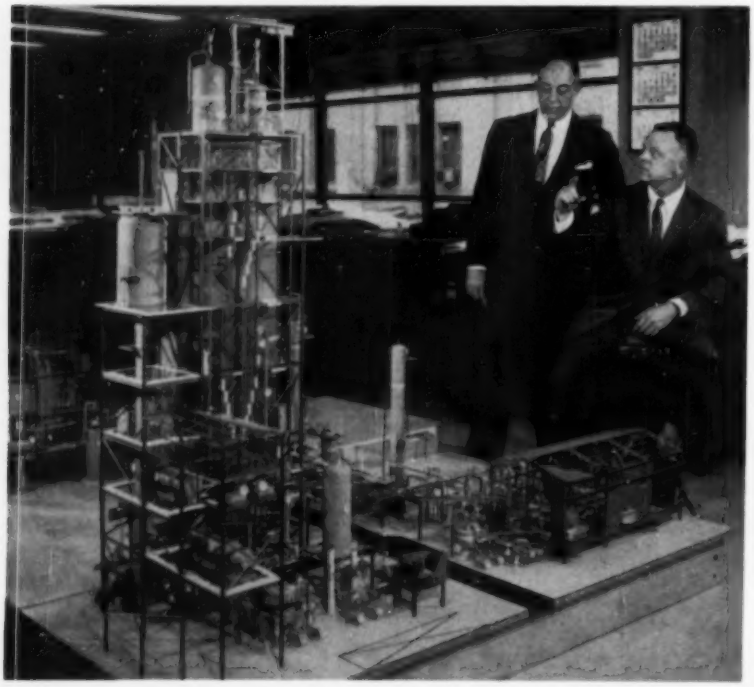

Models are important in plant design. This one was built by M. W. Kellogg for a SunOlin urea plant. SunOlin president J. I. Harper (right) and v.p. S. S. Johnson study model.

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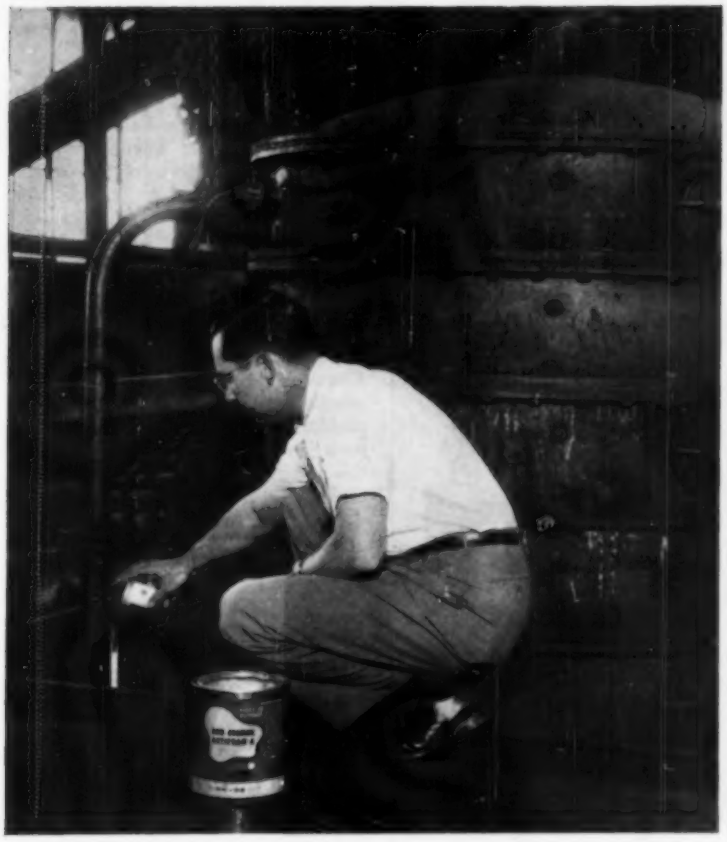

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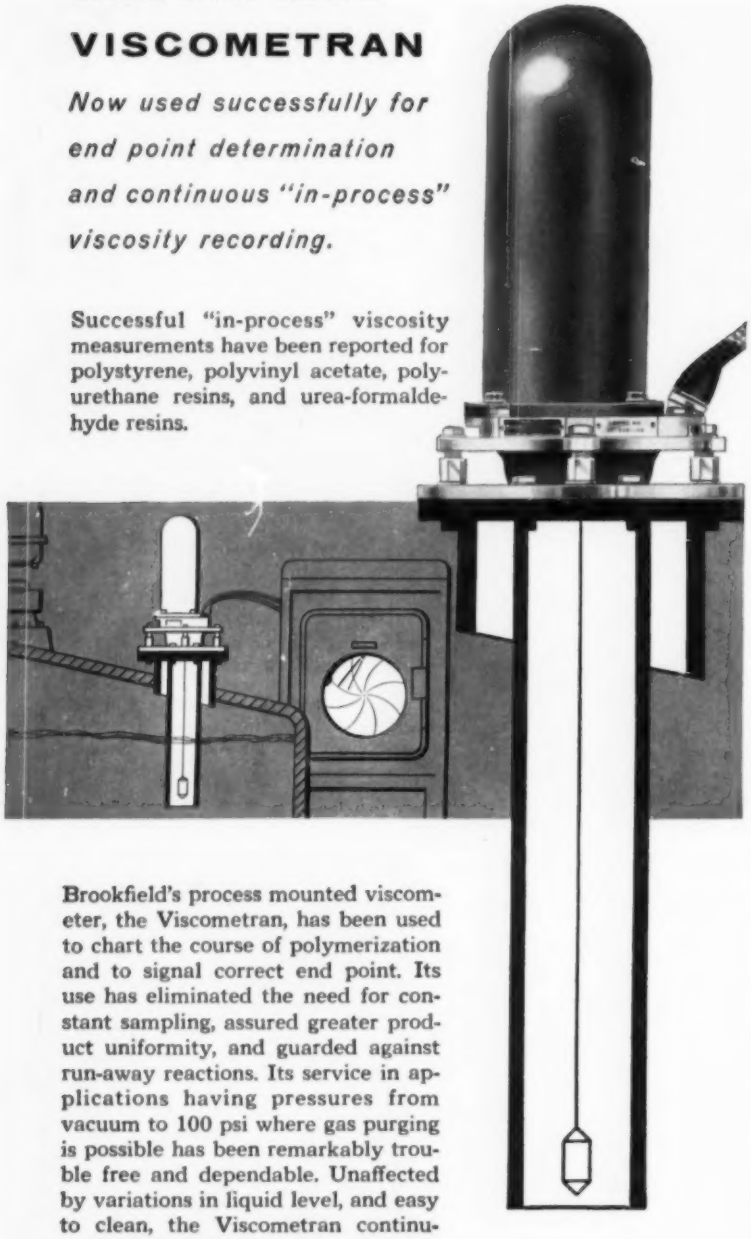

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Book reviews

from page 8

THE FOUNDATIONS OF CHEMICAL KINETICS, Sidney W. Benson, McGraw-Hill Book Co., New York (1960), 703 p., $13.50.

Benson's textbook will appeal to two groups of chemical engineers: (1) the practicing engineer whose casual interest in chemical kinetics is suddenly heightened by a need for background in chemical kinetics, and (2) the postgraduate student, either studying in graduate school or informally at home.

Based on a sampling of some dozen topics in the text, the reviewer recommends *The Foundations of Chemical Kinetics* to both the student and the practicing engineer. The text is unpretentious; the author does not aim for a general reference text. However, the material covered is set forth concisely in lucid English with sufficient detail that the casual reader may read a section of the book without extensive reference to preceding or following sections.

The reader will find it necessary to search elsewhere for ramifications of mass and momentum transport as they affect chemical kinetics. Some reference is made by the author to engineering literature; in particular, remarks are directed to the subject of control of temperature and briefly to that of conducting experiments in flow reactors. Nevertheless, the chemical engineer who wishes to broaden his understanding of the chemical aspects of kinetics might well start with Benson's book.

As a textbook for use in chemical engineering graduate courses in chemical kinetics it can prove useful. The pertinent parts of the text could be covered in a three-semester-hour course. The author proposes for this purpose the use of Part I, the "Phenomenological Description of Chemical Rate Processes," together with most of Part IV, "Reactions in Condensed Phases." Topics of interest could be selected by the instructor from Part II, "Statistical Methods for Treating Systems of Large Numbers of Particles at or near Equilibrium," and more especially from Part III, "The Kinetics of Homogeneous Reactions in Gases."A series of fifty-three short problem statements follow a five-part appendix. Both name and subject indexes are provided at the end of the text.

The instructor in a chemical engi-

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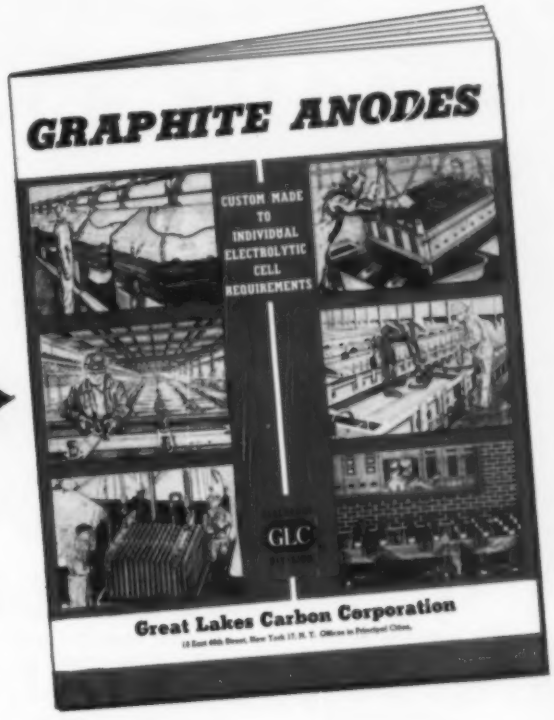

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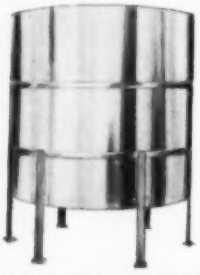

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Book reviews

from page 10

neering graduate kinetics course might choose to use this text as a principal text or as a supplementary reference text. The decision will depend on whether the course is oriented more or less in the direction of applied kinetics. At any rate, the chemical kinetics text by Benson provides a satisfactory companion piece for the engineer-oriented McGraw-Hill text by S. M. Walas. As mathematical descriptions of the unit operations become more sophisticated, more time will become available in chemical engineering graduate courses for the material covered by Benson. #

Reviewed by M. M. Gilkeson, Chemical Engineering Department, Tulane University, New Orleans, Louisiana.

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THE LATEST EDITION of American Standard Letter Symbols for Rocket Propulsion is now available. This standard, approved by the American Standards Association in September, is the result of collaboration between the American Rocket Society and the Institute of the Aeronautical Sciences. The 22-page booklet, sponsored by ASME, contains letter symbols for principal concepts, subscripts and superscripts. It also has an appendix and alphabetical index by concepts. Priced at $2.00, (ASA Y 10.14-1959), it is published by American Society of Mechanical Engineers, 29 West 39th Street, New York 18, N.Y. The 1958 Book of Standards has been brought up to date with the completion of the 1959 Supplements. The book, a triennial in ten parts, is updated by means of these annual supplements. Each part supplement revises the corresponding part of the book by including new standards and revisions adopted during the previous year.

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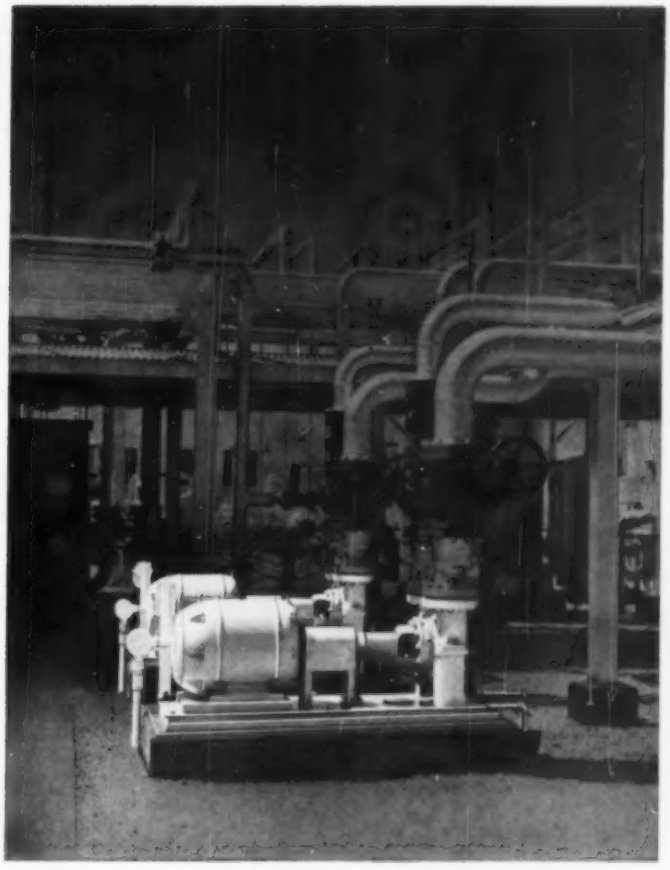

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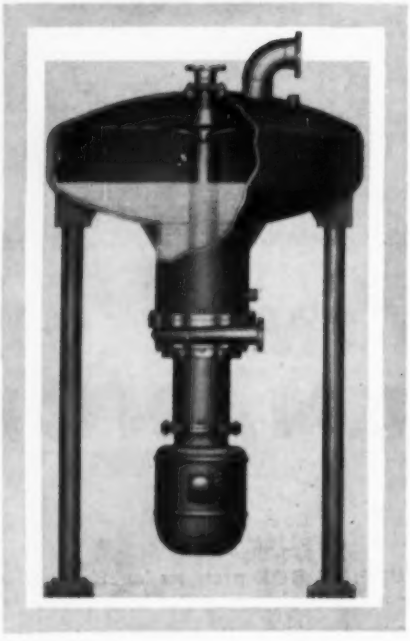

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Materials lag seen critical for national defense

Souped-up research program, stockpiling of rare materials urged by National Academy of Science—National Research Council.

"THE LAG IN THE development of new metals, ceramics, and plastics is, at this moment, holding up the development of nuclear-propulsion systems and space vehicles, as well as better missiles, rocket motors, naval vessels, and electronic devices for which theoretical designs now exist," reports a committee of the National Academy of Sciences—National Research Council. "Important national security programs, particularly those in defense, atomic energy, and space, are currently up against a materials barrier because the properties of most presently available materials are inadequate for the high-performance end items that must withstand severe temperature, pressure, radiation, corrosion, and stress environments."

Recommendations

Five general recommendations are advanced by the Committee on the Scope and Conduct of Materials Research:

- Greater centralization of responsibility, more support for, and more effective coordination of Government-sponsored materials research and development programs;
- Government incentives to encourage research and development on new and improved materials;
- Assurance of adequate U.S. supplies of every chemical element or material to support full production and use of new and improved materials;
- Improvement and acceleration of the dissemination of research information;
- Strengthening of the universities in their dual role of training scientists and engineers, and of doing basic research.

Stockpiling urged

Potential as well as present use should be one of the criteria for stockpiling of rare materials, says the report. Cited are tellurium and rhenium as rare metals not now on any stockpile list, but whose future uses could be substantial for thermoelectric and high-temperature uses respectively. Tantalum, also, although already listed for stockpiling, "may be in far greater demand than anticipated through potential usefulness in high-temperature alloys and compounds and in electronic capacitors."

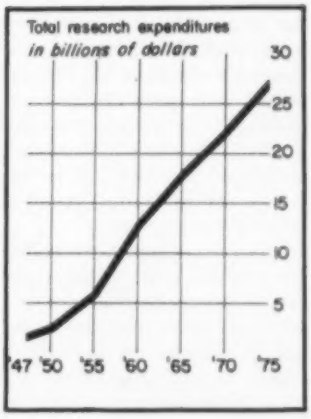
There are no magic administrative or technical solutions to the materials problem, according to the committee report. What is needed is significant strengthening at every level of activity.

No coffee break for control computer

Spare time between duty cycles is not being wasted by the RW-300 general purpose control computer recently put into on-line operation by B. F. Goodrich at its Calvert City, Ky., vinyl chloride and acrylonitrile plants. Chemical analyses of mass spectrometer data on important process streams are performed automatically by the computer in three-minute intervals between its regularly scheduled control functions.

Research Outlay Seen at $27.8 Billion in 1975

"The greatest organized assault upon the unknown that society has ever undertaken" is scheduled for the next 15 years, according to a year-long study just completed by American Marietta Co. Research expenditures in the U.S. will total $27.8 billion in 1975, compared to $13.5 billion in 1960, predicts the report. Basis for American Marietta's confidence in the future—a continuing rapid increase in population, a new and greater period of construction, an "era of unprecedented technological progress."



SCOPE

continued

You can't take it with you

What know-how or technical knowledge can an engineer take from job to job without running foul of the law—here are the results of an EJC survey.

". . . THE OBVIOUS FACT must be faced that in many cases an engineer is hired for a job because of his experience on previous jobs.

". . . we are more interested at the time of the employment interview in the over-all competence, versatility, and diversified background of an individual rather than specific areas of information he might have gained in prior employment.

". . . as long as there are no legal entanglements, such as patents, publications, etc., we would logically expect to cash in on their experience.

"We do not expect to make use of knowledge of a secretive nature which employees acquired at other employment . . . we expect a gentlemens' agreement in reverse when the employee leaves our organization.

". . . generally speaking, over the past twelve years we have adopted the philosophy that one keeps out more than he keeps in when he closes the doors of his research.

"We are presently adopting a plan whereby secret and confidential information will be more fully explained and defined to the employee at the time he signs the employment contract."

". . . as a practical matter, we have found that lasting protection can be given to this sort of thing only by attempting to establish a patent position on the subject . . . when an engineer leaves our employ, we do not require that he sign any agreement to limit the ideas, or information, or know-how that he has gained with us."

100 companies—100 policies

The above quotes are sample replies to a survey questionnaire sent to some 800 major companies by the Committee on Employment Conditions of Engineers Joint Council. The survey was an attempt by EJC to penetrate the ethical and legal jungle surrounding the matter of employer-employee contractual relationships as they concern transmittal and use of engineering knowledge, particularly in the category of so-called "trade secrets."

Personal responsibility

Rare, according to the survey, are companies which investigate prior agreement obligations at the time of employment. This fact, says EJC, points up "an evident reliance on the engineer's responsibility to determine largely for himself what information he can carry and use from job to job." Hitch is that such agreements can form, and have, the basis for legal actions with both the engineer and the new employer as defendents. The time would seem ripe for some effort towards coordination of policies and attitudes on the part of both companies and individual engineers.

Low temperature nitrogen fixation

Nitrogen-fixing chemicals have been separated from bacteria and stimulated to perform their function outside the bacterial cell, according to a report from Du Pont's Wilmington, Del., Experimental Station. Possible practical application—an advance in the study of catalytic reactions in general, since enzyme activity is said to "far surpass man's accomplishments in the field of catalysis."

Tibetan medicine anyone?

Shotakovsky balsam, Minsk retort root pine tar, Tibetan medicinal products, are some of the pharmaceutical and chemical products being offered for export by Amtorg Trading, Soviet export agency. More conventional items on the list include hydrogen peroxide, methanol, certain radio-isotopes.

Character profile of the engineer

They "feel they are more ambitious, creative, analytical, introverted, and emotional than other employees," concludes L. E. Danielson of the U. of Michigan in a newly-published book on "The Characteristics of Engineers and Scientists."

The prophesies of Nostradamus

Department of Commerce crystal ball focused on chemical industry prospects for 1960.

THE DEPARTMENT OF COMMERCE has put its team of soothsayers to work on the outlook for the chemical industry in 1960. Here are the highlights of their predictions:

Domestic sales of *alkalis and chlorine* will be at least 5% above 1959. Exports of *caustic soda and soda ash* may fall off slightly as new foreign plants come into production.

Hydrofluoric acid sales will be about 110,000 short tons—up 10% from 1959.

Sulfuric acid—a good year, with gross output climbing over the 18 million ton mark, up about 4%.

Synthetic fertilizers expected to maintain 1959 pace. A few spot shortages anticipated in phosphoric acid and ammonium sulfate.

Plastics will reach a new high of approximately 6.5 billion pounds, up about 10% over 1960. This, however, is a slight slackening of the growth rate during 1959.

Shipments of *industrial gases* are slated for a 10% rise in 1960, paced by *oxygen, nitrogen, argon,* essential in metal production and fabrication, and in the rocket, space, and atomic energy programs.

Pesticide prospects are "encouraging." According to the Dept. of Commerce report, the ICA expects to procure about 60 million pounds of 75% DDT and 100,000 pounds of 75% dieldrin for the malaria eradication program.

Naphthalene, cyclic crudes, cyclic intermediates, should all be up slightly over 1959.

Pharmaceuticals are expected to show "the usual annual 10% increase."

A $1.1 billion market for *soaps and synthetic detergents* is seen for 1960, as the shift from soap to detergents slackens somewhat.

Cosmetic sales will reach a new peak in 1960, says the Dept. of Commerce, estimate is $1.6 billion.

Paint, varnish, and lacquer sales will top the $2 billion mark for the first time.

Foreign trade to increase

Intensified worldwide competition will characterize foreign trade in 1960, according to the report. U. S. exports are expected to exceed the $1.5 billion record set in 1957 (1958 exports slipped to $1.4 billion). Imports will climb drastically, probably above $500 million, compared to about $300 million in 1959.

New domestic facilities are estimated to call for capital expenditures approximately 20% higher than in 1959.

Rubber-neck tours for visiting engineers

Foreign engineers passing through New York are tired of seeing nothing but the Empire State Building and the Radio City Music Hall, according to A. E. Dembitz of Singmaster & Breyer, chairman of a new committee formed by ASCE. The committee intends to furnish engineer hosts and guides on a volunteer basis to show visiting firemen some of the more interesting and exciting engineering wonders of the City. Other towns please copy.

Shale oil in Brazil

Part of Brazil's petroleum needs may be supplied by extraction of petroleum products from shale oil. The country is said to have oil shale deposits second only to those of the United States, with potential oil recovery estimated at more than 300 billion barrels. Advisor to the Brazilian government on oil shale mining will be Tell Ertl, chief mining engineer of Cameron and Jones, Denver consulting engineering firm.

High priority for anhydrous hydrazine

A "multi-million dollar" plant for production of anhydrous hydrazine, rocket and missile fuel, will be built for the Air Force at Saltville, Virginia, by Olin Mathieson Chemical, only present commercial producer of the material in the U. S. Engineering studies and acquisition of facilities are beginning at once, says Olin Mathieson.

ENGINEERING PERSPECTIVE
THROUGH A

VENTURI

Venturi tubes were first used for measuring fluid flow. While this application has increased substantially, the use of the Venturi in important unit process operations has increased even more. A Jet-Venturi combination is literally the heart of many important manufacturing processes.

During the first several years of the forty-two year history of our firm, we specialized entirely on steam jet vacuum pumps (ejectors). Many thousands of these are in service throughout the country and in most foreign countries. Our tradename, EVACTOR, is an important word in engineering circles. While steam jet vacuum pumps are still our major item, other applications of Jet-Venturi equipment are increasing constantly. With the exception of closely related products such as barometric condensers, CHILL-VACTORS, and CONVACTOR* systems, all of our activity is directed to the one purpose of making Jet-Venturi units more efficient, more dependable, more economical, and to apply them to an increasing number of industrial applications.

JET REFRIGERATION
JET COMPRESSORS
JET CONDENSERS
JET HEATERS
JET PUMPS
JET MIXERS
JET REACTORS
JET ABSORBERS
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SPECIAL JET VENTURI UNITS

*The CONVACTOR is a dual condensing system for economic and efficient recovery of high boiling components from water vapor.

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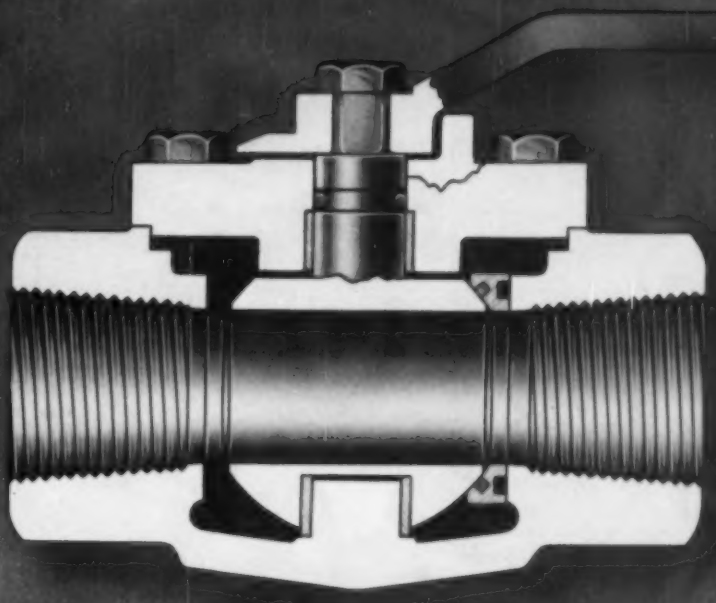
For more information, turn to Data Service card, circle No. 85

For more information, circle No. 137

...how can 1 valve replace 3?



Better **FLOW** *than a* **GATE...**

but, unlike gates, the *FLO•BALL* valve doesn't freeze or jam . . . it never leaks . . . the seats don't score . . . it requires no maintenance . . . and just a ¼ turn opens or closes it.

Better **SEALING** *than a* **GLOBE...**

but, unlike globes, *FLO•BALL* gives zero leakage . . . in both directions *without* seat distortion . . . closes easily without massive operators . . . gives more than twice the flow . . . and the fastest action of any valve made.

Better **RELIABILITY** *than a* **PLUG...**

but, unlike plugs, *FLO•BALL never* needs lubrication . . . never freezes, never leaks, requires no maintenance . . . yet it has greater flow capacity than any plug . . . and the *lowest* torque in the industry.

FLO•BALL® does it...and does it better!

Hydromatics, Inc.
LIVINGSTON, NEW JERSEY

FLO-BALL

Mail this postage-free card today!

Bearing-fixed ***FLO•BALL*** valves are stocked with flanged or screwed ends, full or reduced port, in standard sizes from ⅛" to 10". They are made to standard ASA dimensions in carbon steel and 316 stainless steel.

Gentlemen:

Perhaps your bearing-fixed ***FLO•BALL*** valves can fill my applications. I require valves

for_____

_____ in these sizes_____.

I now use ball valves in these sizes_____.

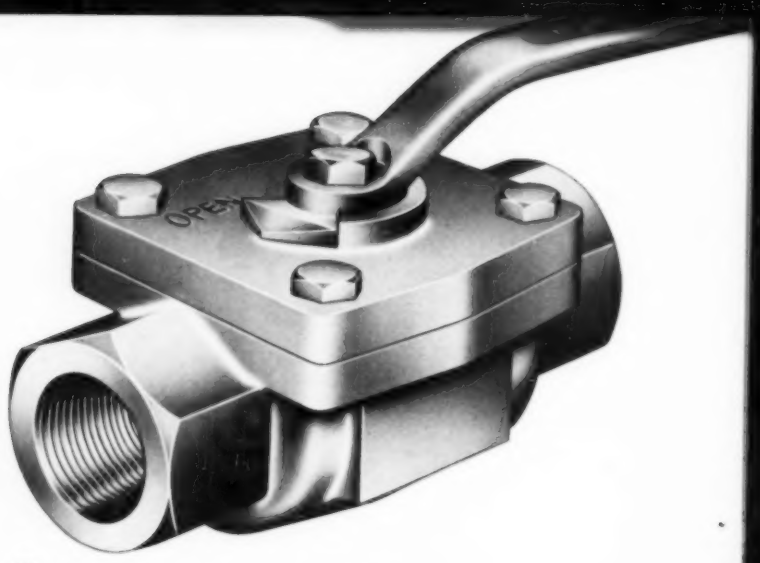
PLEASE: ☐ Have salesman call ☐ Send technical data

My name_____ Position_____

Company name_____

Address_____

City_____ State_____



...how the FLO•BALL® reduces your valve costs 3 ways!

1. Reduce initial costs . . . *by using fewer valves per system. FLO•BALL valves are used in place of gates, globes, or plugs.*

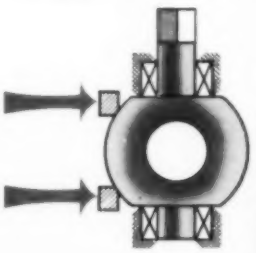
2. Reduce inventory costs . . . *by standardizing on one type valve for all applications requiring gates, globes, or plugs.*

3. Reduce maintenance costs . . . *the FLO•BALL high reliability means less maintenance . . . no lubrication, no freezing, positive sealing. The top loading and replaceable seat reduces overhaul and start-up costs.*

Principles of Operation

In the bearing-fixed FLO•BALL valve all pressure forces exerted on the ball are transmitted to low-friction bearings. The pressure balanced seat results in a sealing force which is designed to insure positive sealing without seat distortion, and to minimize seat-resisting frictional forces. The combination of these low frictional forces accounts for the extremely low operating torque.

FLO•BALL VALVE
Fixes ball • Floats seat



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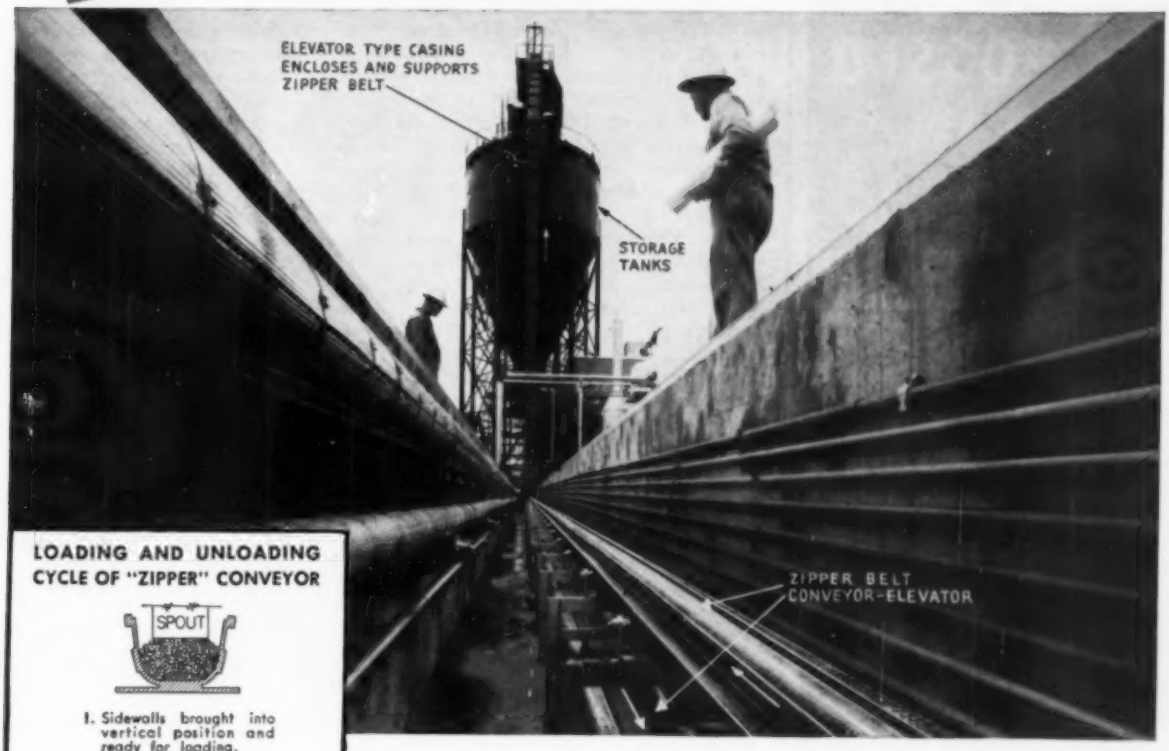
EXCLUSIVE

"ZIPPER"* CLOSED-BELT CONVEYOR-ELEVATORS

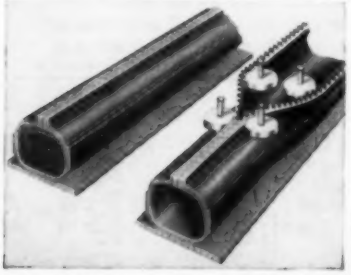


LOADING AND UNLOADING CYCLE OF "ZIPPER" CONVEYOR

1. Sidewalls brought into vertical position and ready for loading.

2. Flexible tube completely closed for conveying and elevating.

3. Rubber ZIPPER belt open for discharge, cleaning and return run.



Upper left unit closed and loaded. Lower right shows how belt is opened and closed by system of ball bearing rollers. (Rollers are mounted on a rigid framework)

CONVEYS AND ELEVATES BY CONTINUALLY WRAPPING MATERIAL IN A PACKAGE... MOVING THE PACKAGE AND ITS CONTENTS TO A NEW LOCATION AND GENTLY UNWRAPPING IT!

Literally a moving material-carrying conduit, the ZIPPER Conveyor is capable of transporting bulk materials in any plane, to considerable heights and around obstructions. Its great advantage is that bulk materials may be conveyed within the belt completely sealed and dust-tight. Material doesn't slide, isn't scooped, pushed or thrown but is gently carried over great distances without breakage, agitation or segregation. The ZIPPER Conveyor-Elevator provides versatility of layout and profitable material handling advantages you won't want to overlook.

*PATENTED

WRITE FOR BULLETIN 349

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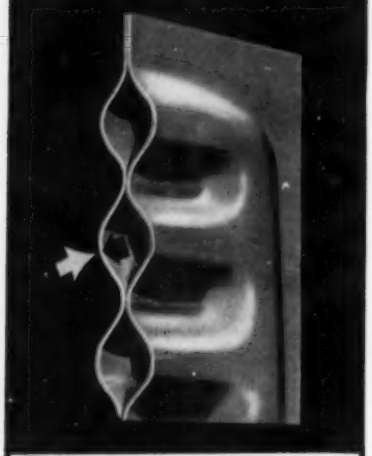
ANOTHER
DEAN
EXCLUSIVE

NEW!
HEAVY GAUGE
EMBOSSED
DEAN
PANELCOIL

12-GAUGE "ELC" CARBON STEEL
14-GAUGE "ELC" STAINLESS STEEL



Dean Panelcoil offers longer service life under corrosive operating conditions. Its greater structural strength in the heavier gauges is ideal for use as the shells, sides, bottoms and partitions of processing and storage equipment.

Don't forget the other Dean Exclusive Features: (1) Widest Standard Panel Widths Available—in 5 widths from 12" to 29", in lengths up to 143"; (2) Superior Type P and S Panelcoil Designs with exclusive "Slip-Over" Fittings—Fast distribution and heat transfer; (3) Large inlets and outlets for quick start-up and recovery.

Dean Panelcoil is made by seam welding two sheets of metal together, one or both sheets being embossed to form the flow channels. Get the whole story—Dean Data Sheet 15-60 Series and Price Bulletin 259.

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1040 Dean St., Brooklyn 38, N. Y.
STerling 9-5400
Backed by 25 Years of Panel Coil Manufacturing

For more information, circle No. 59

Washington scope

Tariffs and the CPI

THE CHEMICAL INDUSTRY may come off second best at the forthcoming General Agreement on Tariffs and Trade (GATT) Conference planned for Geneva next September. According to well informed Washington sources the consequences will rest squarely on the chemical industry because it has thus far shown a relatively apathetic attitude toward the Geneva negotiation.

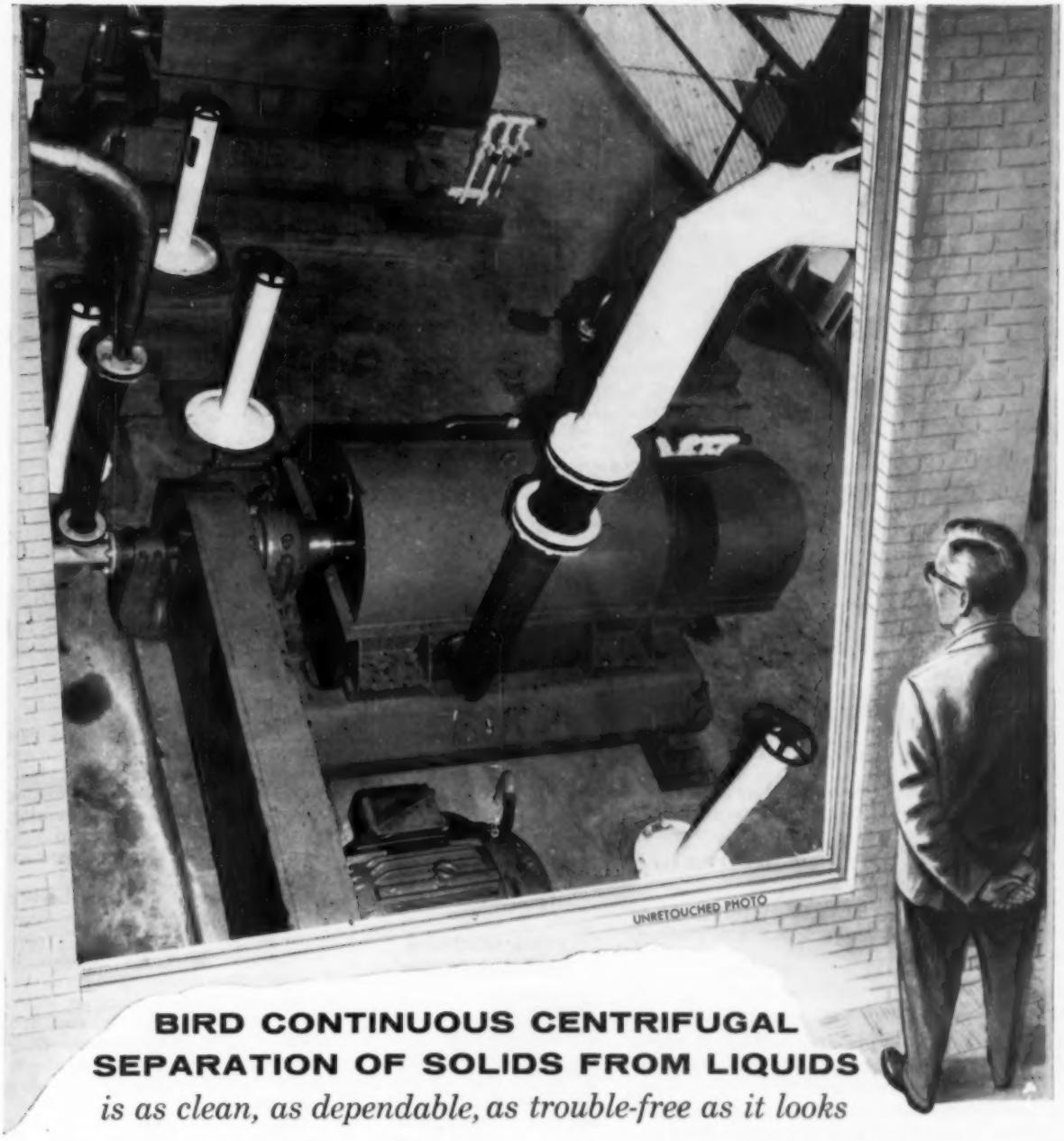
In this column in the March *CEP*, we quoted Senator Clifford P. Case: "Government can and must maintain fiscal and monetary policies conducive to economic growth. It can and must work with other nations, bilaterally and through international agencies, to promote a climate favorable to the international investment and the development of productive enterprise abroad. But government can do only so much. Necessarily, to American business and American labor fall major responsibility for actually doing the job, for demonstrating to the newly emerging nations that economic progress and freedom can go hand in hand." One of the most important instruments for achieving a profitable ready flow of international trade is GATT. Under authority of The Trade Agreement Act of 1934, as extended and amended, and the Trade Extension Act of 1958, the President of the United States is empowered to reduce tariffs, to reduce U. S. duties, in annual stages by not more than 20 percent of the rates existing on July 1, 1958. Alternatively, he may reduce any rate by 2 percentage points ad valorem, or he may reduce to 50 percent ad valorem any rate which is in excess of 50 percent. The law likewise authorizes him to agree to "bind" (i.e. continue) duty-free treatment for articles on the free list or to bind existing duties.

The law provides that before a trade agreement is concluded with any foreign power, reasonable public notice shall be given in order that interested persons shall have an opportunity to present their views to the President or to an agency the President may designate. The Committee for Reciprocity Information is the agency created for the purpose of receiving such views. The function of the Committee is to accord reasonable opportunity to all interested persons to present their views on any proposed trade agreement, or with respect to the operation and effect of trade agreements which are in force, or to any aspect thereof. Many other government agencies are also keenly interested in tariff adjustments since they have an important effect on both domestic and foreign trade. Hence, the Committee for Reciprocity Information looks to many government sources for specific and factual data. Those government agencies, such as Business and Defense Services Administration (BDSA) of the Department of Commerce, which have continuing contact with industry, are looked to for specific information for specific industries. Such agencies, if inadequately informed, can provide only a defense of the industry in general terms and commodity classifications when submitting data to the Committee for Reciprocity Information.

As in earlier conferences, the aim of the Geneva Conference will be reduction of the general level of tariffs and other charges on imports through the exchange of reciprocal and mutually advantageous conces-

continued on page 24

	Total Exports	Total Export Chemical & Allied Products	Total Imports	Total Imports Chemical & Allied Products
	In Millions of Dollars			
1950	10,142	725	8,735	170
1951	14,868	977	10,813	300
1952	15,048	Not available	10,745	244
1953	15,626	819	10,777	293
1954	14,948	1,004	10,232	249
1955	15,390	1,089	11,334	255
1956	18,838	1,248	12,490	274
1957	20,630	1,395	12,920	276
1958	17,693	1,365	12,734	280
1959	17,373	1,493	14,999	347



BIRD CONTINUOUS CENTRIFUGAL SEPARATION OF SOLIDS FROM LIQUIDS

is as clean, as dependable, as trouble-free as it looks

Sturdy, compact solid-liquid separating equipment like the Birds in the picture is a far cry from the sprawling, sloppy, wide open and often complex ways you used to put up with.

There is a Bird to fit the job however large or small. Bowl diameters range from 6 to 54 inches, separating forces from 30 to 3000 gs. Each size is subject to 25 variations in design. You can feed the Bird thick or thin, hot or cold slurries, in varying volumes and consistencies. Solids can be fine or coarse.

The Bird Research and Development Center is equipped to determine the one best Bird for you. Recommendations will be unbiased because Bird builds batch and screen centrifugals, drum and pan vacuum filters and pressure filters, too. Before you invest in solid-liquid separating of any kind, why not get all the facts and figures.

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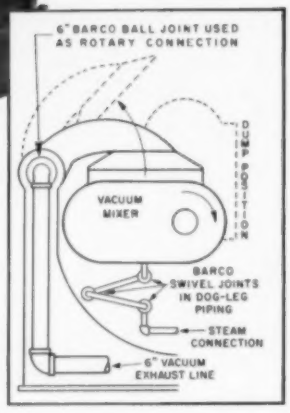
BIRD CONTINUOUS CENTRIFUGALS

For more information, turn to Data Service card, circle No. 148

BARCO FLEXIBLE JOINTS

—Aid Machine Builders!

BAKER PERKINS, INC. —On the big vacuum mixer shown at left (*also see sketch below*) a 6" *Barco Ball Joint* serves as a simple, dependable pivot point rotary vacuum connection to the movable hood of the tilting mixer trough. Below the mixer, three *Barco Self-Aligning Swivel Joints* are used to form a flexible "dog leg" steam piping connection.


6" BARCO BALL JOINT USED AS ROTARY CONNECTION
DUMP POSITION
VACUUM MIXER
BARCO SWIVEL JOINTS IN DOG-LEG PIPING
STEAM CONNECTION
6" VACUUM EXHAUST LINE

3 TYPES OF JOINTS:

1. **SELF-ALIGNING SWIVEL JOINTS** for Dog Leg Reciprocating Swivel Movement.
2. **BARCO ROTARY JOINTS** for Continuous Rotation.
3. **FLEXIBLE BALL JOINTS** for Angular-Flex Movement and Alignment.

BAKER PERKINS, INC., Saginaw, Michigan, one of the world's leading builders of mixing equipment for chemical and process industries, is a long time user of *Barco Swivel, Rotary, and Flexible Ball Joints.* Here, as in other industries, designers of machinery have developed many ingenious, money-saving applications that FUNCTION PERFECTLY over long periods of time. One of the big advantages of these Barco Joints is that they have NO BALL BEARINGS—they handle *steam* at almost any required temperature (also many corrosive chemicals) without baking dry. NO LUBRICATION REQUIRED. *When you need flexible piping connections on machinery, check with BARCO.* Worldwide sales and service.

FOR DESIGN ENGINEERS—

SEND for these interesting, helpful, illustrated bulletins:
No. 310—"New Type C Barco Rotary Joints for Steam, Water, Hot Oil, Air, Gas, Chemicals."
No. 265—"Barco Self-Aligning Swivel Joints." For service as high as 850 psi, and 750°-1000°F.
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PRODUCTS BACKED BY EXPERIENCE
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BARCO MANUFACTURING CO.
560-F Hough Street • Barrington, Illinois
The Only Truly Complete Line of Flexible Ball, Swivel, Swing and Revolving Joints
In Canada: The Holden Co., Ltd., Montreal

For more information, turn to Data Service card, circle No. 2

Washington

from page 22

sions. In preparation for the conference, each nation is expected to submit in advance to each other nation a list of products on which it intends to request tariff concessions. Naturally, at Geneva, participating country delegates must be ready to announce concessions. Negotiations, initially, are conducted bilaterally and on a selective product-by-product basis. However, a Tariff Negotiating Committee, composed of representatives of all participating countries, functions to coordinate and facilitate the negotiations. In general, all participating nations obtain contractual rights to all the concessions negotiated by each pair of countries and agreed to by all of them for incorporation into the GATT.

Law requires three preliminary actions before a trade agreement is concluded: (1) reasonable public notice must be given of intention to negotiate so that interested persons may have opportunity to present their views; (2) the President must seek information and advice from certain "interested" Government agencies; and (3) U.S. Tariff Commission must recommend to the President "peril points," or rates below which the Commission finds that U.S. duties may not be reduced without causing or threatening serious injury to U.S. industry producing like or competitive products.

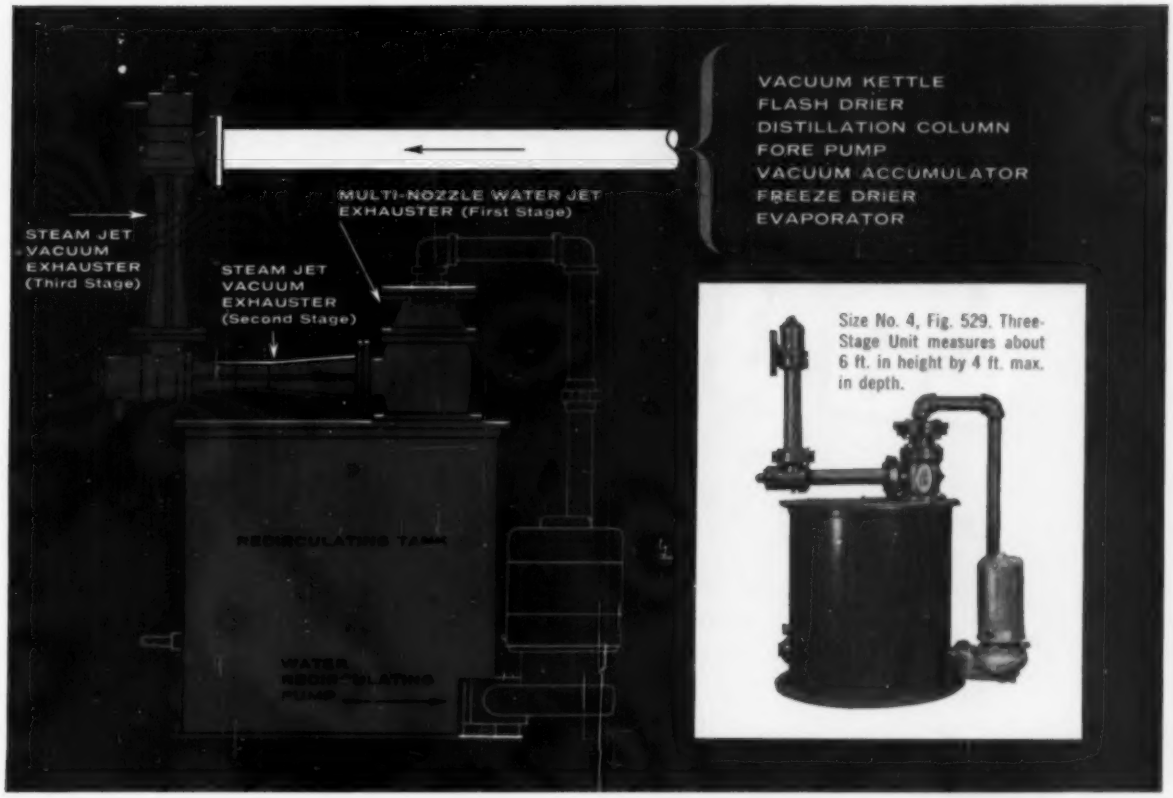
Our government acts through three principal committees: (1) The Interdepartmental Committee on Trade Agreements, or Trade Agreements Committee, representing Agriculture, Commerce, Defense, Interior, ICA, Labor, State, Tariff Commission, and Treasury; (2) the Committee for Reciprocity Information mentioned above; and (3) the Cabinet level Trade Policy Committee.

Based on information obtained through these three committees, a "public list" of items being considered for tariff concessions is published giving dates for filing of briefs and dates for public hearings.

The "public list" covering chemicals to be considered at the coming Conference in Geneva is expected to be published momentarily but is not available at press time.

In considering the importance of the coming GATT Conference it might be well to bear in mind the trend of imports and exports as tabulated in the table on page 22.

J. L. Gillman, Jr.


VACUUM KETTLE
FLASH DRIER
DISTILLATION COLUMN
FORE PUMP
VACUUM ACCUMULATOR
FREEZE DRIER
EVAPORATOR
MULTI-NOZZLE WATER JET EXHAUSTER (First Stage)
STEAM JET VACUUM EXHAUSTER (Third Stage)
STEAM JET VACUUM EXHAUSTER (Second Stage)
Size No. 4, Fig. 529. Three-Stage Unit measures about 6 ft. in height by 4 ft. max. in depth.

PRODUCE HIGH VACUUM QUICKLY & ECONOMICALLY

with this "Packaged" Hydro-Steam Unit

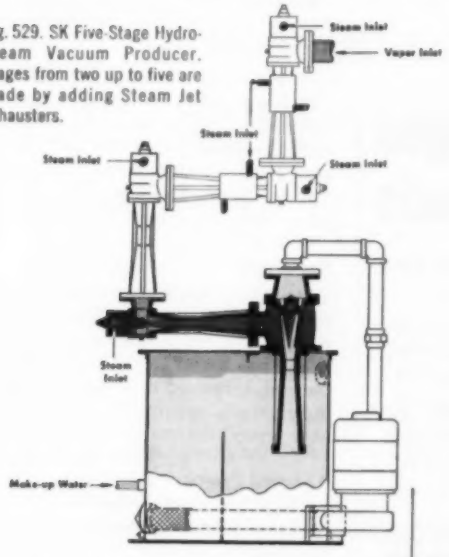


Fig. 529. SK Five-Stage Hydro-Steam Vacuum Producer. Stages from two up to five are made by adding Steam Jet Exhausters.

The unit shown is a "packaged" vacuum producer designed to operate at ground level. Using plant steam and make-up water, it will produce the low suction pressures required for many operations in chemical, food, and petroleum processing plants.

These units are made in a range of sizes in single-stage, two, three, four, and five-stage types. Depending upon size and type, units in this line will provide suction pressures ranging from atmosphere to 1.5 in. Hg abs (single-stage) up to 0.25 mm Hg abs to 25 microns Hg abs (five-stage).

SK "Packaged" Vacuum Producers offer specific, worthwhile advantages. They are simple in construction, are self-contained, compact, require little head room or floor space, are easily installed. Unlike mechanical vacuum producers, contamination presents no problems. They are operated easily, produce vacuum quickly, are economic, can be used intermittently or continuously as desired.

New Bulletin 5H-HS gives complete details on application, construction, operation including suction pressures provided and data on steam consumption and make-up water required. Send for a copy.

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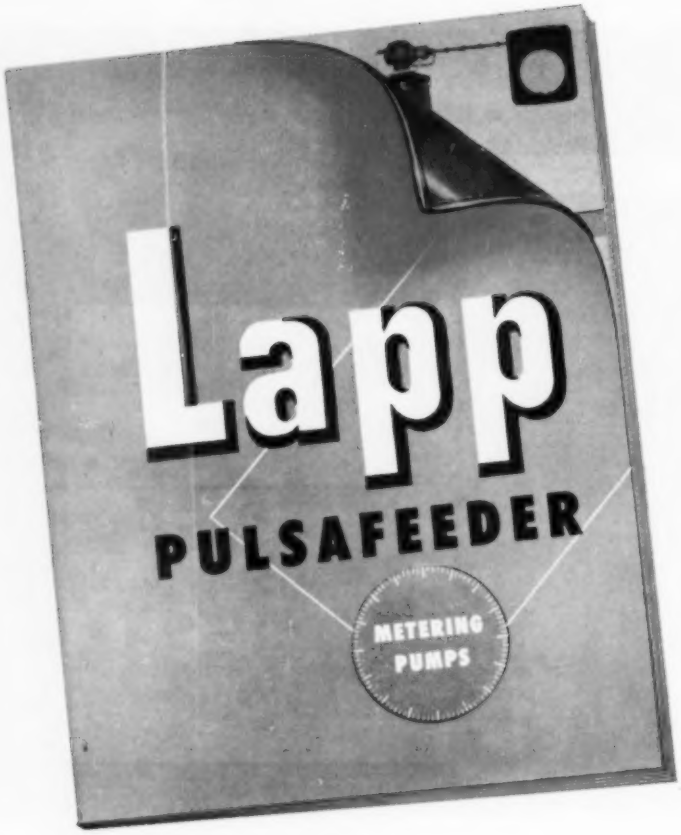

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letters to the editor

Local sections and the National

I SUPPOSE THE VARIOUS sections know what they are doing when they allow section membership without membership in the national, but I also know a large number of our graduates become members of the local sections and become quite active in them. How many of these ultimately become members of the national organization? You probably can find out better than I can. However, it appears to be unusual, in reference to organizations like the A.C.S., A.I.M.E. and other engineering societies, to have membership in a local section of a national organization without simultaneously having membership in the national organization. I don't know whether the A.I.E.E. or the A.S.M.E. follows this practice but I do know that the A.I.M.E., of which I have been a long time member, does not have membership in the local section unless the man is a member of a national organization. I think at this point you would have more chemical engineering graduates becoming members of the national organization even if they participate only in local section activities.

CHARLES L. MANTELL
Chairman, Dept. of Chem. Eng.
Newark College of Engineering
Newark, New Jersey

Reader Mantell refers to a situation which has come in for considerable discussion within the Institute—no definitive answer. Some local chapters have made national membership mandatory, most have no requirement other than local membership.—ED.

Red China

THANK YOU VERY MUCH for the tear sheets from the March CEP. We have shown these to a number of visitors to the office and they were uniformly pleased, surprised or amazed. I rather imagine you will receive many favorable reactions from your readers.

PAUL S. FEINSTEIN
Assistant Program Director
Foreign Science Information
National Science Foundation
Washington, D. C.

Reader Feinstein refers to the two items on Red China; one on nuclear progress, one on polymer chemistry.—ED.

continued on page 28

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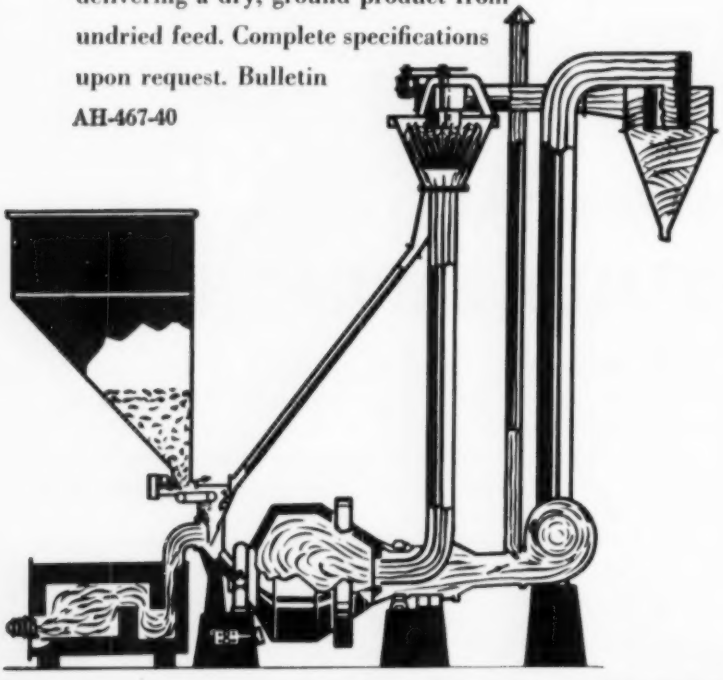

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Letters to the editor

from page 26

Analog systems

IN THE FEBRUARY ISSUE of the "Chemical Engineering Progress" you had an extremely interesting and educational series of articles concerning analog and digital computers and computer applications in control and design of different processes. I was surprised to see that Link's concept of special purpose computation systems for industrial control was missing from your listings and that our unique function generators, digital as well as analog, designed for control and simulation of different processes, were not mentioned.

For your information I attach to this letter brochures describing our line of Dialog systems and components which utilize both analog and digital technologies. These basic building blocks can be applied in either straightforward or in hybrid fashion and provide unheard of advantages regarding economy and reliability, basic requirements for "on-line" control equipment.

Link's Analog and Digital Function Generators, which are described in the literature attached, provide for the first time possibilities of programming computation equipment directly from collected or calculated process data. Thus, we can eliminate the extremely difficult and time-consuming data reduction problems which presently have to be solved for the development of analytical expressions describing the process characteristics.

I hope that this information concerning Link's activity in the field of control computers will be of interest to you and that it will complete your valuable investigations in this field.

GEORG M. HERZFELD
Special Projects Staff Engineer

Shelter spaces

ALTHOUGH ATOMIC DEFENSE engineering investigations have been conducted during the past ten years on the loading and response of structural systems subjected to blast loading, on shelter radiation shielding systems, and on the shelter environmental problem, little consideration has been de voted to the overall integration of these and other necessary systems into shelter spaces suitable for habitation during emergency conditions. Only by looking at the defense shelter problem on an integrated architectural engi-

continued on page 30

DATA FOR COST ESTIMATION

Falls Industries provides this 32-page report to keep busy processing people up-to-date on the latest designs and costs of impervious graphite processing equipment. Sixteen different types of equipment are covered from Hydrochloric Acid Absorbers and Cross-Bore Heat Exchangers to Rupture Disks and Thermowells. Information supplied includes standard sizes, dimensions and costs.

Because Falls Industries is so active in developing new and improved impervious graphite processing equipment, this cost and standards report is periodically revised. This present report is the third revision since this service was inaugurated. It is available on request to Engineering Department . . .

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Letters to the editor

from page 28

neering systems and habitability basis can logical, economical shelter be provided for the Nation. A comprehensive integrated research program investigating the architectural engineering aspects of the shelter problem—as well as the psychological, physiological, sociological, and economic aspects—has therefore been long required.

Just to formulate the integrated shelter problem and to determine valid answers by such a research pro gram is definitely not sufficient. The architectural and engineering graduates of today are not being equipped with the fundamentals necessary to cope with typical problems related to survival in the nuclear age—e.g., problems such as planning and designing for protection against the effects of nuclear weapons. The architectural and engineering curricula do not today include at either the graduate or undergraduate level, opportunities for students to become aware of nuclear defense and the relationship of it to the planning, design, and construction of all buildings in the future. Further, only a very few architect-engineer firms of the Nation today have a capability to handle such problems.

Thus faced with these problems—need for an integrated defense shelter research program, need for university courses for today's student, and need for short courses for the practicing architect and engineer—A Shelter Research and Study Program was developed.

It is considered that the Program—its objectives, scope, and details—is of sufficient importance to the survival of our Nation in this nuclear age that it should be brought to the attention of all government officials—federal, state, and local—having related defense responsibilites, of all professional societies of related disciplines, and of architect-engineer firms who will be involved in handling such problems. It is hoped that all members of these organizations having responsibilities for the planning and design of all buildings, structures, and facilities be aware of the nuclear defense planning and design problem and its implications.

Merritt A. Williamson, P. E.
Dean, College of Engineering & Architecture
Pennsylvania State Univ.

The program includes two, two-week seminars, July 10-22, and July 24-August 5.—Ed.

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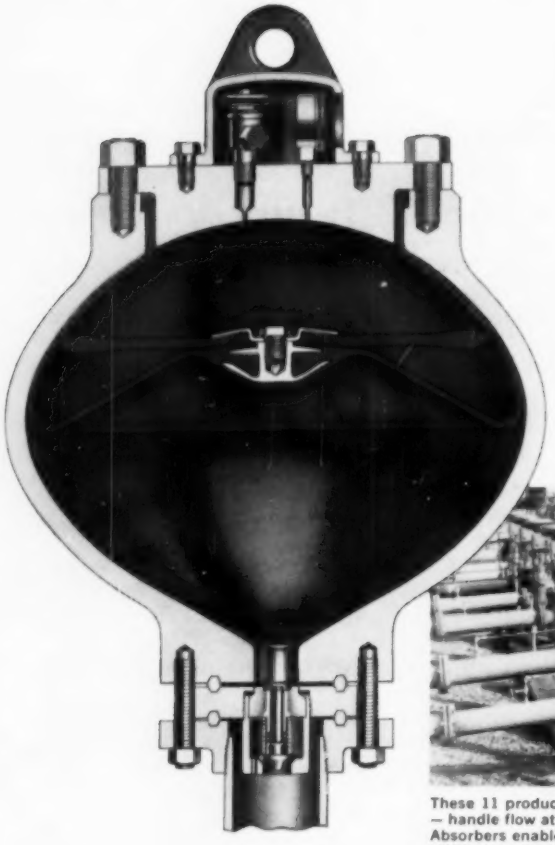

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For more information, turn to Data Service card, circle No. 16

How to put the chill on radioactive wastes?

THERE'S HARDLY A CHEMICAL PROCESSING company around today which is not involved one way or another in handling radioactive materials. Be they relatively modest isotopes, experimental or full-fledged reactors, or even industrial X-ray machines, each contains a built-in hazard requiring the utmost caution—and respect—in its handling. Generally speaking, the safe operating procedures developed during the early days are still adequate. However, the potential hazard inherent in disposal of wastes has provoked considerable discussion. Hence, it should come as no surprise that there's a trend afoot to integrate national, state, local and industrial planning to provide close control, supervision, and research in the areas where radiological operations have an effect on environmental health. This will probably mean a Federal agency, most likely the Public Health Service, becoming the co-ordinating watchdog.

Soaring use compounds problem

The tremendous growth of the radiological field, and the nature of ionizing radiation, has made it a natural for close regulation. Professor Abel Wolman, John Hopkins, stated before a Congressional hearing that the toxicity of ionizing substances are anywhere from 1-10 million times greater than any familiar, orthodox, chemical toxic material so far used in trade. Meanwhile, the amount of curies now being distributed throughout the U. S. as radioisotopes exceeds by many orders of magnitude the radiation from all of the world's radium extracted up to a decade ago. A complicating factor, Wolman noted, is that as isotope usage has grown, the half-life of the isotopes used has grown.

The astronomical growth of nuclear reactors—there are almost 500 in the U. S. now—poses some real problems. Isolation used to be considered the means of avoiding problems in the early days—a scant 12 years ago. This is no longer practical with so many reactors which have gone beyond the field of pure power production and are now used for a variety of applications. Meanwhile, the handling of the wastes becomes a real, practical problem. There is no method for disposal of high level wastes, having a long half-life—from 25 to 5,000 years. The solution to date has been to hold them, and there are about 65 million gallons of this material stored in the U. S.

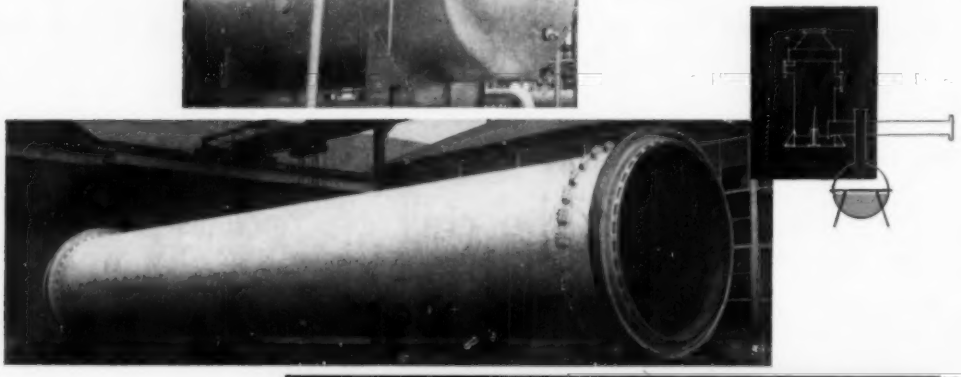
Low-level wastes provide a more immediate, and perhaps more serious, problem. Researchers are hard at work trying to find out what to do with the real hot stuff. Meanwhile, relatively cool wastes from hospitals, research labs and industry have often been simply washed down the drain. In Baltimore, treated sewage is reused for industrial purposes, and discarded radioisotopes have carried through to show up in plants utilizing the treated stream. How these will affect the material being processed, plant equipment, and plant personnel are unanswered questions. What if they were discharged into watersheds?

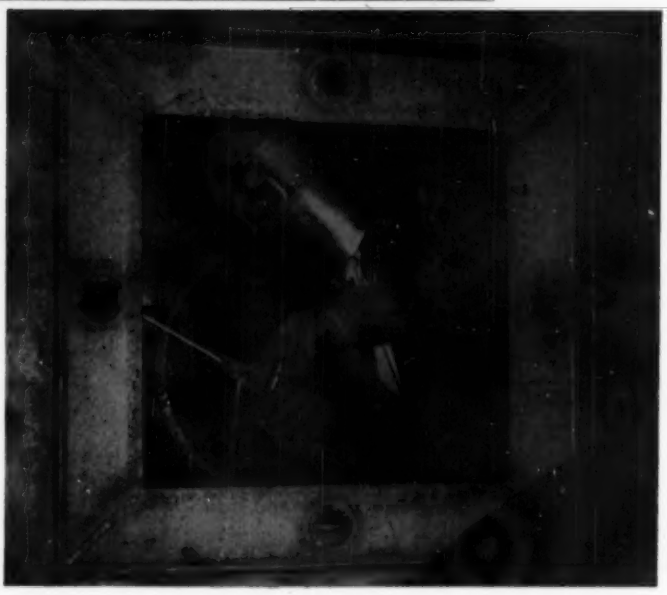
The human race has alway been exposed to radiation. Its worst aspect is that it has cumulative effect. Hence, Wolman testified, somebody (the Government) has to say how much more can be superimposed upon man, and then somebody has to see to it that the limit is being adequately policed.

Needed—trained personnel

The questions and problems are not being ignored. The Atomic Energy Commission will be spending $49 million this year for work in biology and medicine and more next year. And the PHS has jumped squarely into the subject of radiological health. A token program in 1958 has grown to where $6.2 million is being requested for the coming fiscal year. Dr. David E. Price, Assistant Surgeon General, says the primary need is for individuals trained in the very special aspects of biology, engineering, and physics which encompass the field of radiological health. Just three years ago, only 0.6% of the country's sanitary engineers were primarily trained in this area.

Industry has a stake in the overall program, for it is faced with being a growing user of radiological techniques. It is sure to be asked to cooperate in any venture which is developed. And one is sure to be outlined soon, for Congress wants to get some action in time for the 1961 budget.





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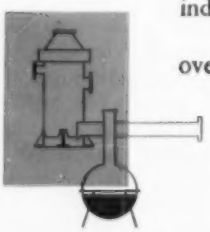

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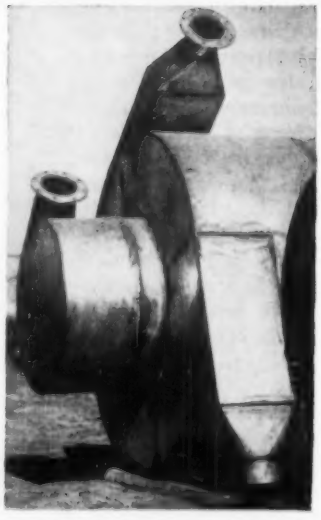

Top: one of a series of A. S. M. E. code stainless steel feed and flash tanks for United Gas Pipeline Company. Center: an 8′ OD x 60′ dryer, composed of one-third solid type 316 stainless steel, two-thirds type 316 20% clad, with interior end cone of Hastelloy C Bottom: Stainless steel cyclones produced for the Fish Engineering Company.

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opinion and comment

Man's reach must exceed his grasp

WHERE ARE THE PACESETTERS coming from to explore the infinite frontiers of scientific research? This is a question cropping up more and more frequently. One which can't be answered simply by pointing to the enormous expenditure of funds. For as a special National Science Foundation Conference Committee, co-sponsored by leading scientific and engineering societies, notes, modern research teams are frequently preoccupied with goals of relatively small dimensions.

Originality of thought and brilliance of achievement has been limited to relatively few individuals, and the prevailing philosophy will tend to perpetuate this restrictive condition. The NSF committee came up with a report which neatly catalogues the reasons – and what to do. CEP touched on the report in its March issue, but its message deserves to be hammered home, even at the expense of being repetitious.

Unfortunately, it concludes, many forces act upon the young researcher to steer him towards taking the small steps and discouraging the long ones. An entrenched academic conservatism has developed so that research projects usually are chosen which piece out small voids of knowledge. This "hole plugging" is done at the expense of bold new adventures which might have promise of significant discovery. The report notes that research effort tends to cluster around certain localized areas which become well populated and self-perpetuating. A matter of going "along with the crowd," if you will. The result: Soon no more new ideas.

Here's a conclusion which should concern all of us: The scientific and engineering societies have not often indulged in philosophical explorations of the future. Project far enough ahead in a paper and you're asking for criticism, the committee notes. The engineering societies have to enlarge their scope of responsibilities so as to penetrate deeper into the sciences.

Then too, engineering societies have largely confined their attention to areas dealing with scientific and technological principles which have "proven" utility value. Those quotes are the committee's own, as is this very important followup: "This policy can be shortsighted. Today it should be clear beyond all doubt that there are enormous possibilities outside the 'proven' areas that will profoundly influence technology of the future."

Here are some of the group's pointed suggestions:

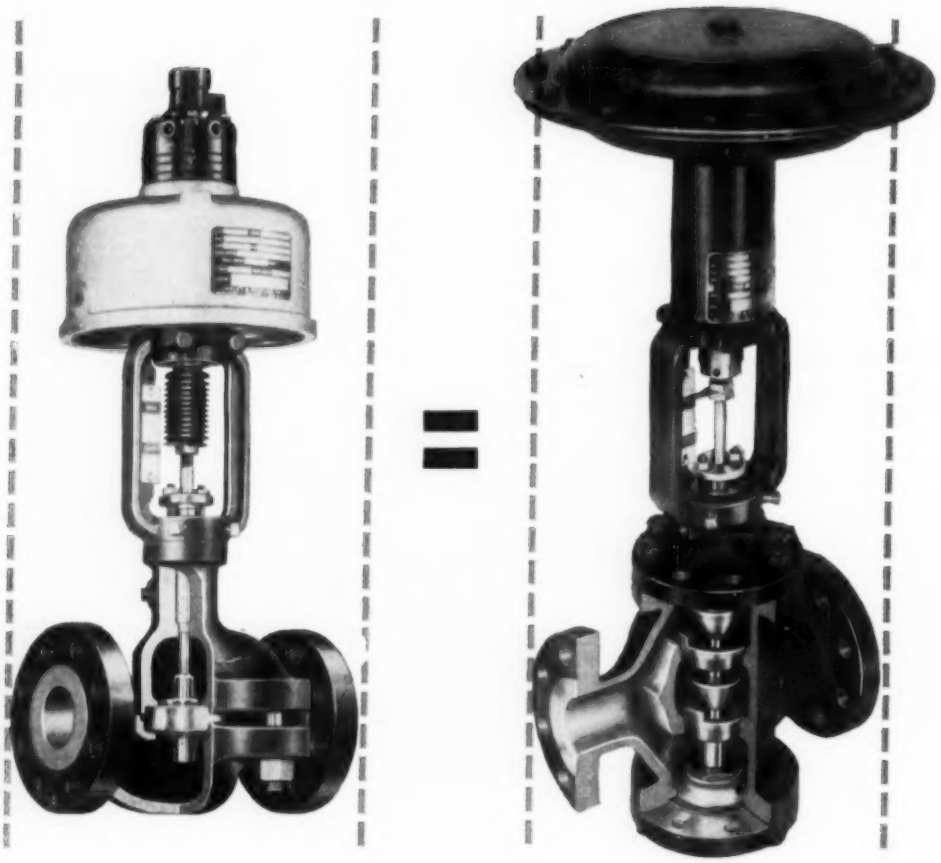
- Doctoral research should encourage more venturesome attitudes.
- Establish practices to increase attendance and participation of talented, young members at society meetings.
- Encourage presentation and publication of papers of a philosophical nature which look to the future of science and technology.
- Develop comprehensive programs for digesting the "state of the art."

A big concern the report notes is entrenched conservatism which can be a powerful obstacle to progress. This can best be typified by the chap who'll say "Creativity is something for the squares."

It isn't. The interest in broad thinking and communicating caused the *Saturday Evening Post* to embark upon its "Adventures of the Mind" series. This high level approach by a mass market magazine resulted in its most popular and successful continuing editorial offering.

More important, we must work and think beyond today and the immediate future. It was well put some time ago, " . . . man's reach must exceed his grasp."

L. R.



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CEP feature

The industry speaks on . . .

Safely operating that low temperature plant

ANOTHER HARDHITTING, shirtsleeves report on safety in operating air and ammonia plants: A subject of vital interest to chemical engineers, by chemical engineers as they speak out at their annual Q. and A. session. This meeting took place at A.I.Ch.E.'s St. Paul, Minn. national gathering, where participants dug deep to find the answers.

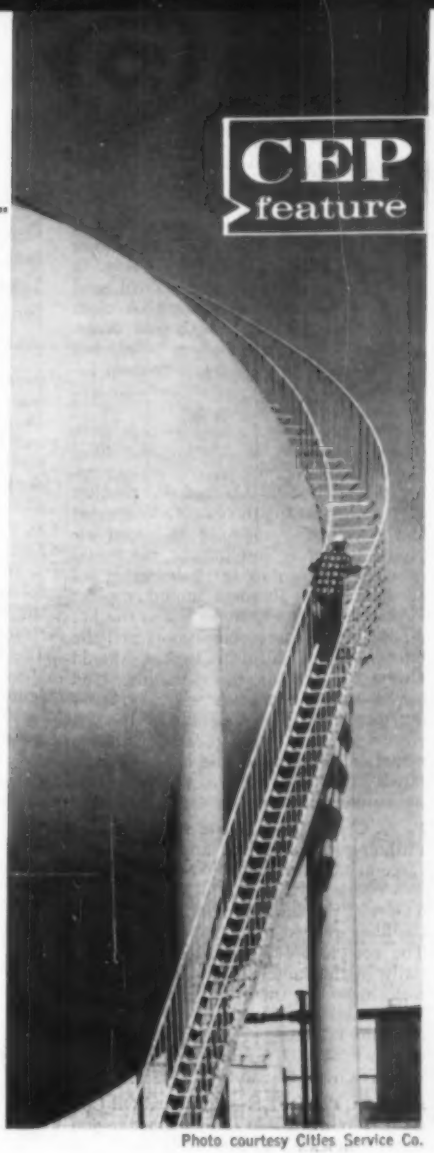


Photo courtesy Cities Service Co.

Air intake impurities

Air separation plant problems begin with impurities in the raw materials.

NORTON WALTON—Atlantic Refining Co., Philadelphia: Air intake, of course, is where the problem usually starts on air separation plants. Its importance will vary considerably with each individual plant, depending on the location of the plant, its surroundings, and what other plants are nearby.

There are two, or perhaps three, methods for removal of hydrocarbons; one is removal from the air intake itself by a device such as the MSA Catalytic Filter which removes them by oxidation; another is removal from the plant by blowdown from the low pressure column, reboiler, or vaporizer; the third is removal by design features at the entrance of the air separation column.

D. L. STOCKBRIDGE—Southern Nitrogen Co., Savannah: We have a nitric acid plant where we have trouble with particulate matter getting into the air compressor. I was wondering if anyone here had American Air Filters or would care to comment on the success of this type filter.

P. T. MARTIN—Spencer Chemical Co., Kansas City: We have American Air Filters on the suction to our nitric acid air compressors and our main air plant air compressors. These filters have been in operation approximately six years and our experience has been very good with them.

G. R. WALTON, JR—Rohm & Haas. Pasadena, Texas: The development of the MSA Catalytic Filter has been of particular importance to Rohm & Haas because of the inherent dangers associated with an acetylene plant located near the air plant at Houston. Generally, the use of a Hopcolite-type filter must be reserved for an essentially oil-free, but relatively clean air stream. At the Houston plant, compressed air at 90 lb. gauge pressure leaves the compressor discharge at 350°F. The compressors are centrifugals, with the usual seals which prevent oil contamination. The outlet air temperature is controlled at 350°F by controlling the interstage cooling temperature. The air is passed through the filter, then chilled in water contact coolers prior to entering the cold box equipment. We believe that at this high temperature level, essentially all butene, acetylene, and propylene are oxidized in the filter. It appears that about 80% of the ethylene is oxidized, as well as lesser quantities of butane and propane. Methane is not affected.

Concerning catalyst activity, samples taken after approximately 14 months service show the activity to be decreased by about 10%. That is, the equivalent percentage of acetylene oxidized requires temperatures 30 to 50°F higher with the used catalyst as compared with an unused sample. The principle problem associated with the filter has been a slow but gradual increase in pressure-drop across the individual cartridges. After

less than one year's operation, the pressure-drop increased from the design pressure of ¾ lb. to 10 lb., at which time the pressure-drop abruptly decreased to 6 lb. This was later found to be a result of the collapse of several of the catalyst containers, which allowed bypassing. In January, the filter was examined and found to be very rusty, the glass cloth prefilter being clogged with iron oxide. New prefilters were then installed, but soon after startup the pressure-drop increased again. By August it was sufficient to cause container collapse.

This time several improvements were made, including: metallizing the filter tank with an aluminum coating, increasing the catalyst blanket of the prefilter area, strengthening the catalyst container, and galvanizing some of the feed air piping. In future installations, we would recommend painting or galvanizing all air feed piping in high humidity plant locations. Especially important is the hot piping between the compressors and the filter tank. Finally, a bypass should always be provided around the filter tank to allow servicing, when necessary, without disrupting plant operations. In conclusion, we are quite pleased with the oxidation efficiency of the MSA catalytic filter, and now believe we have the pressure-drop problem under control.

P. A. CHUBB—Atlantic Refining Co., Philadelphia: We had approximately a three-month test on the MSA filter. It was operating between 375 and 425°F. The inlet propane contamination through the filter, ranged from 1 ppb to 0.2 ppm. The acetylene contamination was essentially in the same range, maybe even a little lower. At these low ranges we got good removal of acetylene. We got essentially no removal of propane. Other components such as butane and ethane were removed to varying degrees.

R. E. BUTIKOFER—Standard Oil Co., (Ind.), Whiting: In the Calumet region sulphur dioxide and iron oxide are found in the atmosphere. These materials deposit in the compressor as iron sulphate which is extremely corrosive. I was wondering if some of you who have centrifugal air compressors have experienced this kind of problem?

J. A. LAWRENCE—U. S. Industrial Chemicals, Tuscola, Ill.: We have been picking up SO_2 and SO_3 for five years and we have completely plugged-up our centrifugal several times. In fact, this year we're going to replace our suction line with stainless steel. We have also ordered from Brown Boveri, the manufacturers of our compressors, stainless steel diffusers in the compressor, and stainless steel rotors. We have installed a Roll-o-matic filter with paper back-up filters and we pick up dust on the order of several pounds a day; which means our suction line is gradually decreasing.

BUTIKOFER—Standard Oil: We have aluminum dryers in our air preparation section prior to the air plant. The aluminum began to disintegrate and carried over into the primary exchangers on our air separation cold box. We had some

W. A. Mason— Chairman of Subcommittee on Safety in Low Temperature Processing Plants.

peculiar pressure-drop buildups in the exchangers, and we began to realize something was wrong. We shut down and found that the tray exchangers were pretty well plugged with aluminum. We are going to go now to a molecular sieve, silica gel type of drying and try that out.

D. C. LAMOND—Canadian Industries, Ltd., Kingston, Ont.: We also have activated alumina dryers. Our dust filter following these is a wool-felt filter—it's the star shape type of filter. We had a strange occurrence with this wool-felt. We had a fire in the filter which destroyed not only the wool-felt, but which ignited the steel support. Our air is at 600 lb. We are not quite sure what happened. The dryers had just been changed. We were in the middle of an upset in the plant and the change of dryers was hurried without too much precooling. We felt that the very dry air might have gone into this wool-felt at around 183°C, and that the fire might have been caused by static electricity. We have since grounded the filter and we have taken proper precaution that our air is not higher than 50°C when introduced in the filters. The filter itself appears to be quite efficient. We have had an opportunity to examine our primary air-oxygen exchanger recently and it was quite clean on the air side.

WALTON—Atlantic Refining: We started off with F1 alumina and had some difficulty with powdering and with carryover into the reversing exhangers. We subsequently changed to H151 alumina and that has substantially stopped the dusting problem. Our felt suppliers says that 250°F is the maximum temperature that felt will stand, so I think that may be the reason for the fire in the C.I.L. plant. But the H151 is certainly more resistant to dusting than F1 is and has been quite satisfactory.

L. B. HENDERSON—Dow Chemical Co., Midland, Mich.: We have an oil-bath filter which removes all dust from the compressor intake and have experienced troubles with dust in the compressor. We have had a dust problem downstream from our dryer. Desiccant dust from the dryer carried through to the expansion turbine caused erosion of the nozzle ring and housing. A Dollinger felt-cartridge filter was installed in the dryer discharge line which has eliminated the problem. Approximately a pint of dust per day is collected by this filter.

T. H. DAVENPORT—Ketona Chemical Corp., Tarrant, Ala: I would like to substantiate Mr. Walton's theory. We changed from F1 to H151 and we have a glass cloth filter downstream of the desiccant and apparently get very little carry over from the H151.

Compressors and dampeners

Damage and fatigue-inducing vibration in compressors are produced by two primary forces: mechanical and acoustic.

G. DAMEWOOD—Southwest Research Institute, San Antonio: For the past four years the Industrial Application Section of the Southwest Research Institute has been engaged in a wide variety of gas industry research problems. One of the programs has been concerned with the problem of pulsation and vibration in reciprocating compressors and associated piping. It is difficult to assess the damage which vibration annually causes throughout the nation. We all know that vibration causes fatigue in mechanical components and, often, failure. Such failure, especially when associated with high pressure gases, can be disastrous.

Even harder to assess is the effect of vibration on the nerves of operating personnel. Probably this last item alone is sufficient justification for vibration control. The problem of establishing an acceptable vibration level is extremely simple, philosophically. You merely reduce the amplitude of vibration until acceptable stress levels are exhibited. Technically, however, the answer to this question is almost impossible, since an absolute measure of fatigue life and of absolute stress levels is not available. There are a variety of techniques and equipment applicable to the measurement of vibration. In general these involve the use of an accelerometer and associated indicating equipment. The most useful measure of vibration is by determining the amplitude of vibration as

a function of frequency, or the so-called "frequency analysis" of vibration.

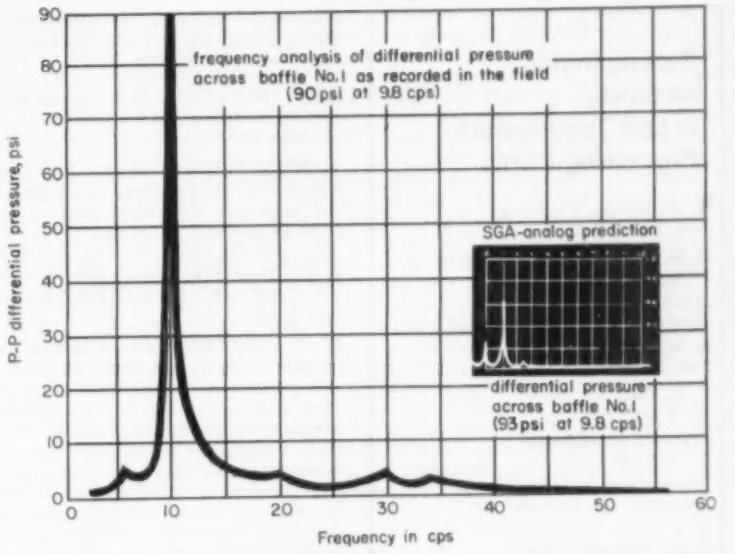
There are two primary forces which produce vibration in compressors and associated piping. These forces are mechanical and acoustic, or pulsating vibration. Of these two driving forces, pulsation is usually the major offender, particularly at the higher frequencies. Therefore, to control vibration in compressors or piping there are two possible alternates. One of these concerns altering the mechanical response of a system. This would tend to merely shift the resonant peaks to a new location or to a different frequency. In some instances this can, therefore, be a solution. If one considers changing the actual frequency of a purchased compressor cylinder however, one immediately runs up against an impossibility. At best this frequency can be moved only a few cycles per minute, not enough, in general, to be a solution to a vibration problem.

The response of the system can be altered in one other way. This involves the proper use of mechanical damping. The addition of damping to the system merely allows the system to withstand greater forces at any given frequency. The next alternate involves reducing the driving forces imposed on the system. Since pulsation is one of the major forces involved, pulsation control is a very useful and practical tool for controlling vibration.

The solution of the complete pulsation problem is complex when one considers optimizing the following parameters: compressor efficiency, pulsation control, vibration control, installation cost, operating cost, and metering accuracy. Many attempts have been made to develop adequate analytical procedures for controlling pulsation. However, even the most advanced methods known today are highly inadequate. Attempts have also been made to use general-purpose computers to solve this problem. The latest attempt at its solution was performed at the Princeton Computation Center. The work published to date indicates a realistic approach to the problem but one which, at best, can be described as naive in its present state.

Analog computers can furnish a quick, efficient, and accurate method for solution of those problems in which mathematical analysis is difficult or impossible. Electrical circuits are usually chosen as a basis for such analogs because of the wide variety of components available and because of the relative ease with which electrical measurements can be made. An electrical analog of an acoustical system is possible since there is a direct correspondence between the flow of gas, the acoustical system, and the flow of electricity in an electrical network.

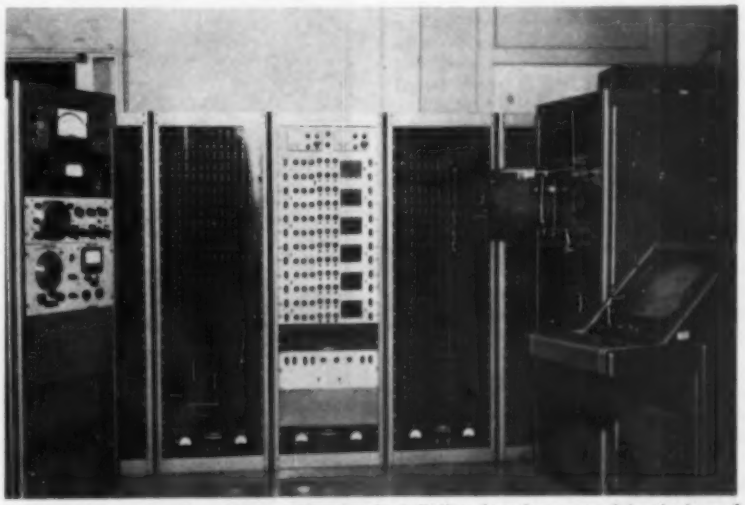
From a comparison of the equations governing the behavior of both systems, it can be shown that the two systems are analogous. There are seven different basic analogies which may be used in the solution of the pulsation problem. The so-called classical analogy, is however, the most practical, and is the analogy chosen for the SGA analog. The analogies used are pressure, represented by voltage, and mass flow, by electric current.



Analog computers can be used to simulate actual field conditions in compressor and piping studies. Photo courtesy Southwest Research Institute.

A system analog, unlike a computer, does not compute the most desirable piping system. It does, however, permit the analysis of the system in the laboratory. This analysis is exactly like performing a field test. Measurements can be made of piping response, steady and dynamic pressures, and mass flows in piping and the compressor card may be immediately observed under controlled operating conditions.

The SGA compressor station analog facility has been used in the design of over 250 compressor stations. Approximately 60% of these installations were studied prior to construction. The remaining 40% represented compressor stations in operation which had some undesirable characteristic such as excessive piping vibration, poor cylinder efficiency, gas metering problems, or the like. The problems studied represent the majority of compressor types found in the industry, including both single- and multistage installations. In addition to natural gas compressor stations, an increasing number of chemical plant problems are being studied. The use of available information and experience on the mechanical response of systems, together with the use of the SGA compressor station analog, have solved a variety of piping problems. It is hoped that current research on the mechanical system will



Southwest Research's analog computer installation has been used in design of over 250 pipeline compressor stations.

Subcommittee on Safety in Low Temperature Processing Plants

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R. W. Rotzler
Monsanto Chemical Co.

N. H. Walton
Atlantic Refining Co.

D. A. White
Smith-Douglas Co., Inc.

The formation of a subcommittee on Safety in air and ammonia plants was suggested more or less casually after the Salt Lake City National A.I.Ch.E. Meeting, September, 1959. It was the opinion of The A.I.Ch.E. Program committee that some attempt should be made to perpetuate the work started by these symposia on safety.

Under the impetus of Nort Walton a representative group comprised of those who had attended and had contributed to previous sessions on the subject were invited to join the subcommittee. Fourteen responded, but subsequent pressure of work forced one to drop out.

The group was formed under the Program committee of the Institute to act in a guidance capacity and to supply leadership for Safety symposia at National meetings. However, consideration is not necessarily limited to air and ammonia plants. Some other areas of possible interest include liaison with the Compressed Gas Association and the preparation of a Standards book of safety procedures in low-temperature plants.

An outgrowth of these symposia has been the published follow-up of these lively question-and-answer sessions in *Chemical Engineering Progress* and subsequent reprinting under one cover of articles pertinent to the subject area.

finally make the problem of compressor piping completely predictable, efficient, and trouble free.

QUESTION—Could you give us some idea of the time required and cost of an investigation?

DAMEWOOD—Southwest Research: Usually we like to spend approximately one week on a single-stage problem, and between one and two weeks on a multi-stage one. We have got the process down to the point where we're talking about something on the order of $2000 per station design.

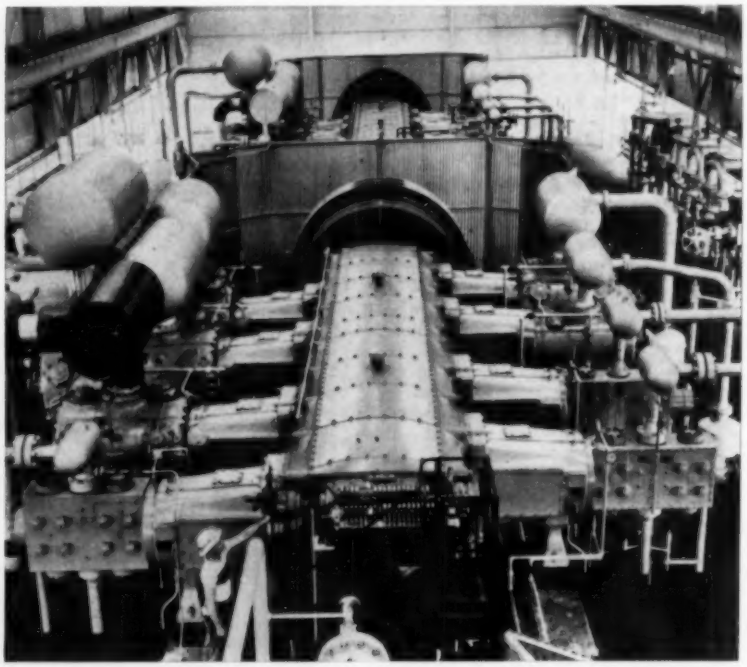
R. F. BOLLEN—Dow Chemical of Canada, Ltd., Sarnia, Ont.: We haven't encountered any serious vibration problems in our plant. We feel that this has largely been due to the patented dampeners which have been installed on the suction and discharge of every compressor. However, I would like to describe the operation of one particular pulsation dampener. This dampener was on the discharge of a four-stage nitrogen compressor, operating at 3000 lb./sq. in.

Shortly after we began operation we found that a very high pressure-drop was developing across the nitrogen system. By surveying the pipe lines and the equipment in between, the search was narrowed down to the pulsation dampener. We watched it very closely and the pressure-drop increased steadily over a period of two or three months. The pressure-drop then suddenly started to build up very rapidly. At this point we promptly shut down and looked into the pulsation dampener. The entire internals were very badly caked with hard carbon.

Damewood

N. H. Walton

We had to sandblast the internals and in some cases drill into hairpin bends and install plugs so that the carbon could be cleaned out. We also found that the discharge valves of the compressor were very badly carbonized. At this point we went back to the compressor manufacturer and also to our lubricant supplier and advised them of our problem. Their answer was that our problem was probably due to excessive lubrication. We cut back to the lubrication rates recommended by both the compressor people and the oil supplier but in about three months we ran into the same problem again. We cleaned out the vessel again and at this time we also made up a spool piece to be installed in place of the pulsation dampener while it was being cleaned. We operated for several weeks with the spool piece in place and noticed that even without the pulsation dampener the vibration of the pipe was no worse than it had been with the dampener installed. It just points out that in designing to reduce vibrations, it is possible to go just a little bit too far, and by introducing unnecessary equipment, you



Reliable compressor operation with minimum vibration is vital to proper plant operation. Photo courtesy Cooper-Bessemer Corp.

can very often run yourself into other problems. We have now removed some of the internals of this particular pulsation dampener so that it acts simply as a surge vessel. This has overcome most of our carbonizing problem.

WALTON—Atlantic Refining: We felt that the problem of pressure-drop in our nitrogen wash system was due to oil vapor getting past our oil filters and ending up in the –300°F exchangers and gradually blocking them up. We had the idea of using radioactive lubricating oil in our nitrogen compressors to try to confirm this, and to find out just where the oil did land. We have a Peerless filter, the first point where oil is removed downstream from the compressors and, sure enough, radioactivity showed up there. The next place we looked for it was downstream of the activated alumina oil filter. But we didn't find it there. So the test results were quite puzzling. Since then, of course, we have found that our oil removal problem has been largely solved by the use of the felt filter and that our problem now is water released when a fresh charge of alumina is placed in an oil filter. The answer seems to be drying the alumina at 350 degrees, or so, for about 4 hr. and having the felt in a separate vessel so it will not burn during this period. On another subject, we had a rod failure in a synthesis compressor since our last meeting. It broke clean, directly across the diameter. There seems to be a consensus among the examining metallurgists that the difficulty was due to the fact that the grain structure was not as fine as it should have been. This grain structure coarseness had shown up in the Reflectoscope examination of the rod at one of the regular intervals in service when we check rods. As a result of this failure and considerable discussions with our compressor manufacturer, we have decided to go to a better rod material in which grain size in the "working-up" of the rod from the original piece of steel receives better control. The new material is 4140. On piston rings, our thoughts at the moment are that we like carbon-asbestos Bakelite rings, where the discharge temperatures are below 335 degrees; and where they're above that, bronze rings. Comparing the projected ring life and liner life seems to us at the moment to be the best thing and also the safest thing, because where you have ring failures with carbon-asbestos Bakelite, you don't wreck your liners as you do with any type of metallic ring. We have also tried something in the last six months with which we're quite happy, and that is asbestos-carbon Bakelite valve discs in the K-type valve (disc valves). Whereas we have had fatigue failures about every three weeks with steel valve discs, we now have gone as much as eight months life with these valve discs.

Hydrocarbon adsorbers

Practical experience proves the value of silica gel for removing undesirable hydrocarbons from the process stream.

FRANK HIMMELBERGER — Air Products, Inc., Allentown, Pa.: Adsorbent purifiers using silica gel made their appearance in air separation equipment about 20 years ago. Their sizing has generally been based on the gel's capacity for acetylene, with some adjustment for other impurities which may also be adsorbed. Their effectiveness has most frequently been measured in terms of acetylene removal. For example, near Cleveland, Ohio in 1945, adsorbers were added in the crude oxygen stream of two existing plants where acetylene concentrations averaged 0.7 and 1.0 cu.m./l. It would come out about 0.9 ppm in one plant and about 1.25 ppm in the other. These numbers were the average for several months prior to installation of the adsorbers. After the adsorbers were added, the average dropped to less than 1% of the original value on analysis. Practical experience such as this has left little doubt as to the utility of the silica gel for acetylene removal. A more complete discussion of adsorptive purification appears in a paper by McKinley and Hsu in CEP 56, p. 80 (Feb., 1960).

Here are some safety rules which should be kept in mind when operating silica gel adsorbers:

1. Stop reactivation on hydrocarbon adsorbers immediately, if the plant is down or if the purity of the reactivating nitrogen is in danger of falling below 90%.

2. Periodically, check the thermostat setting and any flow safety device on the heater unit for proper operation. (One of the most common accidents with regeneration systems is burning out the heating element when there is no flow in the system and the thermostat is not operating properly.)

3. Use the full cycle time allowed for reactivation and cooling the adsorber. Make valve changes as slowly as possible. This is very important if you wish to minimize dusting of the silica gel. (Incidentally, getting back to another question that was mentioned earlier, in our experience we've gone through the cycle from silica gel to F1 alumina, to H151 alumina in dryers; we feel that the H151 is by far the better one. However, since then, some of the silica gel people have come out with new gels with apparently much greater resistance to fracturing. We've not yet tried these in dryers. We have used them in other applications as oil filtering media and find them to be a distinct advantage.)

4. Check a sample of the gel periodically for discoloration. We find that color is a very good indication of the degree of activity of the bed. A very dark colored gel generally will not have the capacity that an orange, tan, or white gel will have; assuming that we start out with white gels.

5. Use the discharge pressure of the reactivation blower to detect powdering or dusting of the gel. (This is just a simple means of determining whether or not pressure-drop is building up on the bed due to dusting.)

6. Do not lubricate valves with hydrocarbon or graphite compounds. (Surprisingly enough, some accidents have occurred in crude oxygen streams where lubricated valves were used.)

7. Keep the valve packing tight and replace when necessary with dry, degreased Teflon-coated asbestos. (Use a nonflammable material and minimize leaks through the valve stems, because hazardous conditions can exist where leakage occurs.)

8. Shorten the operating cycle of the adsorbers as much as possible during periods when contamination of the inlet air is possible from outside sources.

Himmelberger

Shaner

R. L. SHANER—Linde Co., Tonawanda, N. Y.: We use gel extensively in our plants. We have run as long as seven

years without having to replace any gel whatsoever. This, of course, depends entirely on the cycle that you use. It also depends on whether it is being used in a gas phase of a liquid phase adsorber. Our cycle incorporates both. The gas phase adsorbers have extremely high efficiency. The active portion of the bed, the length of the bed that is actually doing the work during the processing time, is one of the important factors contributing to the efficiency of the adsorbers. In the gas phase adsorbers the active portion is extremely short, and as a result the gas phase adsorbers do an excellent job of removing carbon dioxide, acetylene, and other hydrocarbons. In the liquid phase adsorbers the active zone is much longer and, generally, the beds are insufficiently long to completely remove all of the adsorbate as the liquid stream passes through the bed.

W. A. MASON—Dow Chemical Co., Midland, Mich.: I reported in Baltimore that we, at Dow, had originally planned to change the gel in our liquid phase hydrocarbon adsorbers on a three-year schedule. On the first change we found that the first four or five inches of the gel bed were very badly discolored, while the rest of the bed was still quite white. Based on that and on an analysis of the hydrocarbons that were causing these discolorations, we've now switched to a two-year cycle and at present we are continuing to change our gel completely every two years, not because we find that the gel has lost its adsorptive capacity but rather because we feel that this discolored gel contains hydrocarbons which might be an undesirable fuel source within the plant.

Reboilers and vaporizers

Acetylene is the most critical hydrocarbon constituent of low temperature oxygen plants. Its concentration should be limited to 1 ppm.

J. T. HUGILL—L'Air Liquide, Montreal: What level should be allowed in the main vaporizer in regard to concentrations of acetylene and hydrocarbons? The problem is a little complicated because of the two distinct types of oxygen plants: One, where you have a low-pressure plant taking off gas from your low pressure column or through your auxiliary vaporizer; the other, where you're taking liquid off your main vaporizer and pumping it out under pressure. In each case I think the contamination limitations can be varied or relaxed. Some plants use a maximum allowable acetylene of 1 ppm, at which point they must carry out excessive purging. At 2 ppm, they must shut down. This is for acetylene. It's been suggested that if you can analyze specifically for ethylene, you can allow your concentration to rise to 300 ppm before you need to shut your plant down. At 150 ppm, you must carry out double your normal purging. Methane can be allowed to go to 1000 ppm. Again, this was not a unanimous or even a majority opinion at the last two meetings.

There has been much discussion on the problem of how long to leave the liquids in the plants after you shut down, assuming that you're having only a temporary shutdown of anywhere from one hour to 24 or 48 hours. We think that there is no time limit, within reason, on this particular question provided that careful and accurate analyses are carried out during the period in which you are in doubt. If the contamination limits reach your normal safety figures, then you must purge all your liquids before you start up. If, however, things appear to be reasonably normal and stay that way, then you can safely start up without any trouble. There are a lot of cases in which plants have been down for 24 or 48 hours and have been started up without purging off the liquids, assuming that there wasn't much liquid left during that period. Other plants set a definite time limit of one or two or three hours, at which point everything must be dumped, regardless of what the concentration is. With regard to purging during operations in a normal low pressure type plant, where you are taking your oxygen off in the gas phase from an auxiliary vaporizer and oxygen separator and compressing it, we feel that a continuous purge on the separator is necessary regardless of the concentration of hydrocarbons. The purge is set up to be a relatively small percentage of total product. It does not necessarily affect the output of a plant seriously.

Stockbridge

Young

V. M. YOUNG—Naval Air Station, Alameda, Calif.: We first became concerned with pilot and air crew safety from trace constituents in liquid oxygen for breathing, after receiving pilot complaints of odors in their oxygen. As it was necessary to procure liquid samples from aircraft liquid oxygen systems, transfer carts, and storage tanks, as well as manufacturing plants, a method of sampling was needed which would provide:

1. A representative sample
2. Safe use by untrained personnel
3. A minimum of required liquid
4. Shipment according to ICC regulations
5. A way to clean easily and thoroughly

Early in our work it was discovered that the analysis of a gaseous sample did not represent the liquid from which it came unless all the liquid was evaporated. The trace constituents, in such a case, remain in the liquid. It was therefore mandatory that a unit quantity of liquid oxygen be completely evaporated in a container, rather than using gas from the top of the liquid.

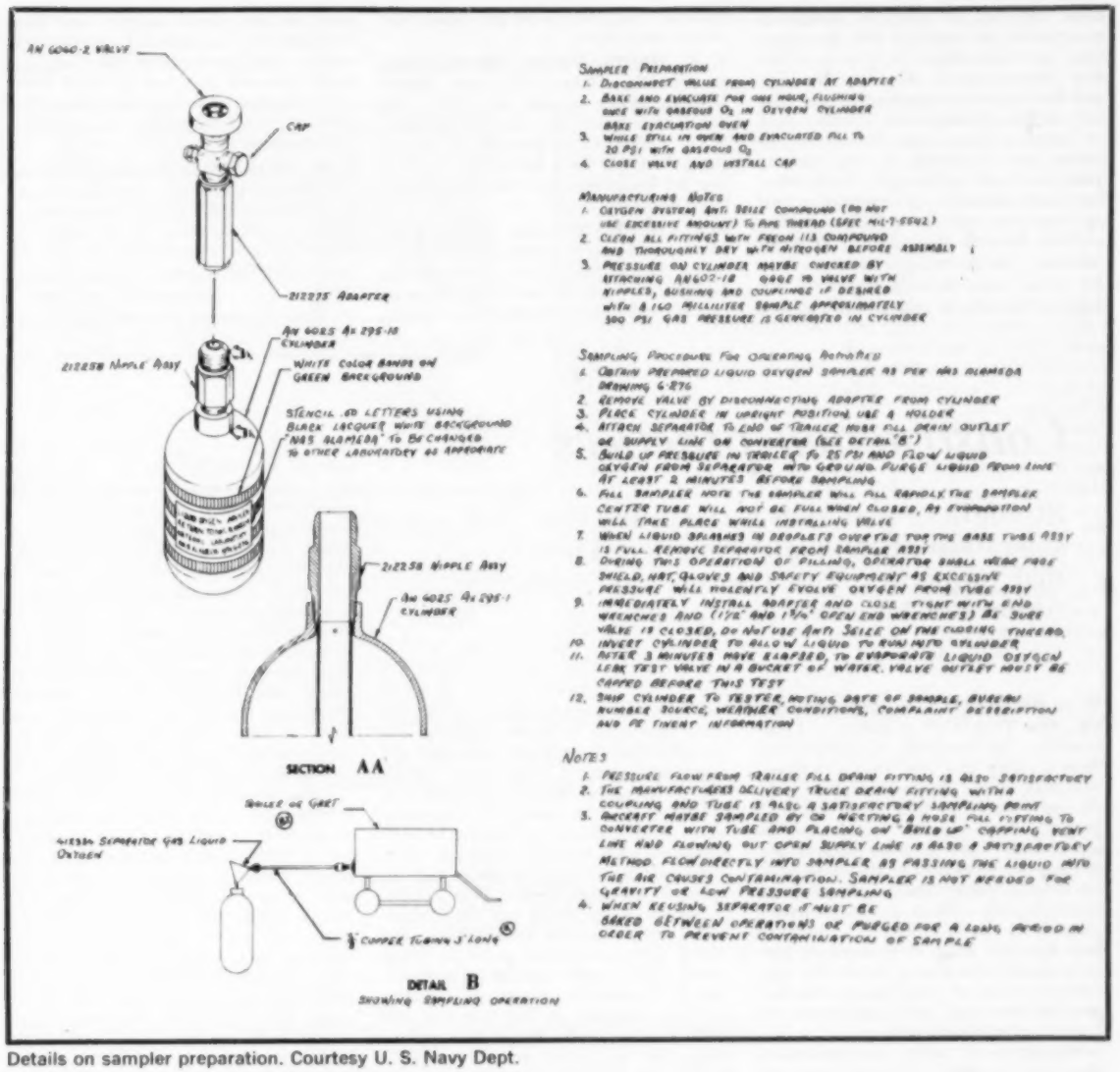
Various types of samplers were encountered in which a quantity of liquid was captured in a container and evaporated. However, the valving was more complex than desired, and further difficulties were experienced with leaks in valves and fittings.

The sampler found best suited for use with liquid oxygen is shown opposite. It consists of a 295-cu.in. gaseous oxygen bottle modified to capture a liquid oxygen sample—a stainless steel tubular cap was welded to the nipple assembly. The sample cup has three 1/16-in. holes drilled in it, Section A-A, which control the size of the oxygen sample such that about 160 ml of liquid is collected during sampling.

The sample itself is introduced into the sample cup as shown in Detail B. The separator shown allows gaseous oxygen to be vented during sampling so that the flow of liquid can be controlled

Hugill

Lamond


AN 6060-2 VALVE
CAP
212275 ADAPTER
AN 6025 4A 295-18 CYLINDER
212258 NIPPLE ASSY
WHITE COLOR BANDS ON GREEN BACKGROUND
STENCIL 60 LETTERS USING BLACK LACQUER WHITE BACKGROUND "NAS ALAMEDA" TO BE CHANGED TO OTHER LABORATORIES AS APPROPRIATE
212258 NIPPLE ASSY
AN 6025 4A 295-1 CYLINDER
SECTION AA
BOILER OR CART
HESSA SEPARATOR GAS LIQUID OXYGEN
COPPER TUBING 3' LONG
DETAIL B
SHOWING SAMPLING OPERATION
SAMPLER PREPARATION
1. DISCONNECT VALVE FROM CYLINDER AT ADAPTER
2. BAKE AND EVACUATE FOR ONE HOUR, FLUSHING ONCE WITH GASEOUS O2 IN OXYGEN CYLINDER BEFORE EVACUATION OVEN
3. WHILE STILL IN OVEN AND EVACUATED FILL TO 20 PSI WITH GASEOUS O2
4. CLOSE VALVE AND INSTALL CAP
MANUFACTURING NOTES
1. OXYGEN SYSTEM ANTI SEIZE COMPOUND (DO NOT USE EXCESSIVE AMOUNT) TO PIPE THREAD (SPEC MIL-T-5542)
2. CLEAN ALL FITTINGS WITH FREON 113 COMPOUND AND THOROUGHLY DRY WITH NITROGEN BEFORE ASSEMBLY
3. PRESSURE ON CYLINDER MAYBE CHECKED BY ATTACHING AN6077-18 GAGE TO VALVE WITH NIPPLES, BUSHING AND COUPLINGS IF DESIRED WITH A 150 MILLILITER SAMPLE APPROXIMATELY 500 PSI GAS PRESSURE IS GENERATED IN CYLINDER
SAMPLING PROCEDURE FOR OPERATING PERSONNEL
1. OBTAIN PREPARED LIQUID OXYGEN SAMPLER AS PER NAS ALAMEDA DRAWING 4-276
2. REMOVE VALVE BY DISCONNECTING ADAPTER FROM CYLINDER
3. PLACE CYLINDER IN UPRIGHT POSITION USE A HOLDER
4. ATTACH SEPARATOR TO END OF TRAILER HOSE FILL DRAIN OUTLET OR SUPPLY LINE ON CONVERTER (SEE DETAIL "B")
5. BUILD UP PRESSURE IN TRAILER TO 25 PSI AND FLOW LIQUID OXYGEN FROM SEPARATOR INTO GROUND. PURGE LIQUID FROM LINE AT LEAST 2 MINUTES BEFORE SAMPLING
6. FILL SAMPLER NOTE THE SAMPLER WILL FILL RAPIDLY THE SAMPLER CENTER TUBE WILL NOT BE FULL WHEN CLOSED, AS EVAPORATION WILL TAKE PLACE WHILE INSTALLING VALVE
7. WHEN LIQUID SPLASHES IN DROPLETS OVER THE TOP THE BASE TUBE ASSY IS FULL. REMOVE SEPARATOR FROM SAMPLER ASSY
8. DURING THIS OPERATION OF FILLING, OPERATOR SHALL WEAR FACE SHIELD, HAT, GLOVES AND SAFETY EQUIPMENT AS EXCESSIVE PRESSURE WILL VIOLENTLY EVOLVE OXYGEN FROM TUBE ASSY
9. IMMEDIATELY INSTALL ADAPTER AND CLOSE TIGHT WITH END WRENCHES AND (1/2" AND 1 1/16" OPEN END WRENCHES) BE SURE VALVE IS CLOSED, DO NOT USE ANTI SEIZE ON THE CLOSING THREAD.
10. INVERT CYLINDER TO ALLOW LIQUID TO RUN INTO CYLINDER
11. AFTER 3 MINUTES HAVE ELAPSED, TO EVAPORATE LIQUID OXYGEN LEAK TEST VALVE IN A BUCKET OF WATER. VALVE OUTLET MUST BE CAPPED BEFORE THIS TEST
12. SHIP CYLINDER TO TESTER, NOTING DATE OF SAMPLE, BUREAU NUMBER SOURCE, WEATHER CONDITIONS, COMPLAINT DESCRIPTION AND PERTINENT INFORMATION
NOTES
1. PRESSURE FLOW FROM TRAILER FILL DRAIN FITTING IS ALSO SATISFACTORY
2. THE MANUFACTURERS DELIVERY TRUCK DRAIN FITTING WITH A COUPLING AND TUBE IS ALSO A SATISFACTORY SAMPLING POINT
3. AIRCRAFT MAYBE SAMPLED BY DISCONNECTING A HOSE FILL FITTING TO CONVERTER WITH TUBE AND PLACING ON "BUILD UP" CHARGING VENT LINE AND FLOWING OUT OPEN SUPPLY LINE IS ALSO A SATISFACTORY METHOD. FLOW DIRECTLY INTO SAMPLER AS PASSING THE LIQUID INTO THE AIR CAUSES CONTAMINATION. SAMPLER IS NOT NEEDED FOR GRAVITY OR LOW PRESSURE SAMPLING
4. WHEN REUSING, SEPARATOR IT MUST BE BAKED BETWEEN OPERATIONS OR PURGED FOR A LONG PERIOD IN ORDER TO PREVENT CONTAMINATION OF SAMPLE

Details on sampler preparation. Courtesy U. S. Navy Dept.

to a steady stream. After the cup is filled, the valve assembly is attached to the sample container and tightened securely. As the liquid evaporates it is collected in the main chamber of the oxygen bottle and the sample is then ready for shipment.

Detailed sampler preparation, manufacturing notes, and procedure are included above. Copies are available to anyone desiring a copy from Materials Laboratory of NAS, Alameda, Calif.

BOLLEN—Dow of Canada: We have had our air plant in operation now for approximately four years and until recently acetylene has not been a problem. We analyze on a routine basis and have never found anything that amounted to more than a fraction of a part per million. About two months ago, shortly after a new plant which is fairly close to our plant came on stream, we picked up acetylene for the first time. We immediately started checking analyses. We increased the purging as much as possible and waited for the down-drop in acetylene content. It didn't come about. Instead, it went up over one part per million. As we were already purging as much as we could, all we could do was to continue taking samples and analyzing. Eventually the acetylene content went to a high of 2.3 ppm. Our shutdown limit at that time was set at 3 ppm. Since the wind was coming from the direction of the new plant, we went and checked over this plant, trying to find the source of acetylene. We could find nothing leaking there. However, they did have an acetylene system where a number of cylinders of acetylene were tied into a common header with a safety valve attached to it. After checking the system over, we connected the vent from the safety, which normally vents to atmosphere, to an absorption train for analysis and we did pick up a trace of acetylene that was leaking through the safety valve. It was the only source of acetylene we could find but apparently it was enough to give us a problem.

C. P. ANDERSEN—Linde: I'd like to comment on holding time of liquids in the vaporizers. We use a recirculation system which continuously recirculates oxygen liquid through a silica gel adsorber to remove any dangerous contaminants during normal operation. With this system we keep the acetylene and dangerous hydrocarbons to a very small quantity. Acetylene concentration has always been below the detectable limit. In this way we see no danger in holding liquid for extended periods of time during shutdown. We've held it for at least a week in some cases. In some cases, we actually add liquid oxygen to the main column for extended shutdown to prevent the liquid from boiling dry. One

other comment on extended shutdowns is pertinent in regard to the gas phase silica gel adsorbers. If you have no flow through these adsorbers the CO_2 and hydrocarbons deposited at the inlet will migrate through the adsorber until an equal loading exists throughout the entire bed. Therefore, if you start up your plant with a silica gel adsorber that has been down for an extended period of time, you may drive CO_2 or hydrocarbons through the adsorber into the columns. The main requirement we have for down time is with regard to the silica gel adsorbers; namely, have a clean adsorber ready to go on line when you restart your plant.

R. K. SIMMS—Phillips Chemical Co., Bartlesville, Okla.: We have found nitrogen oxides in our air plant. We don't know where they are coming from. We're interested in knowing if any of the rest of you have found them and if you did find them, how did you look for them and how often?

G. S. COCHRANE—Sun Oil Co., Philadelphia: We have found nitrogen oxides in our liquid oxygen also. I think the highest concentration was N_2O. We analyze for it by concentrating the contaminants in the liquid oxygen and then analyzing the concentrated contaminants with a mass spectrometer. We have also found NO and NO_2 but in much lower concentrations. We feel that the N_2O is inert and is not dangerous. It is a normal constituent of air.

R. W. ROTZLER—Monsanto Chemical Co., Texas City: We also have found N_2O in our cold system, originally, I think, in regeneration of the silica gel filter bed and subsequently in our reboiler. We found it by analyzing samples with a mass spectrometer and with a 10-meter dispersive infrared instrument.

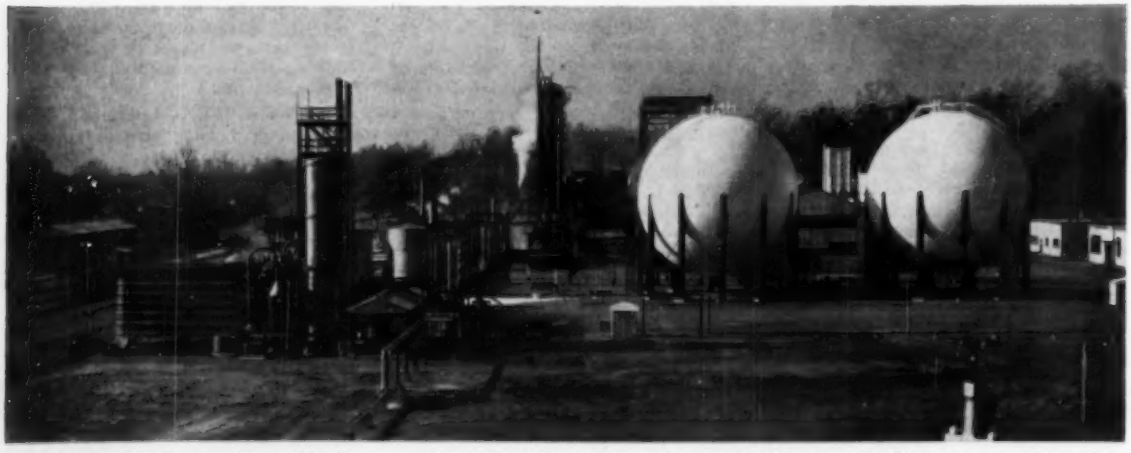
Construction practices

Strength of materials is the prime consideration of the plant designer. Thermal properties, and fracture and corrosion resistance are key factors.

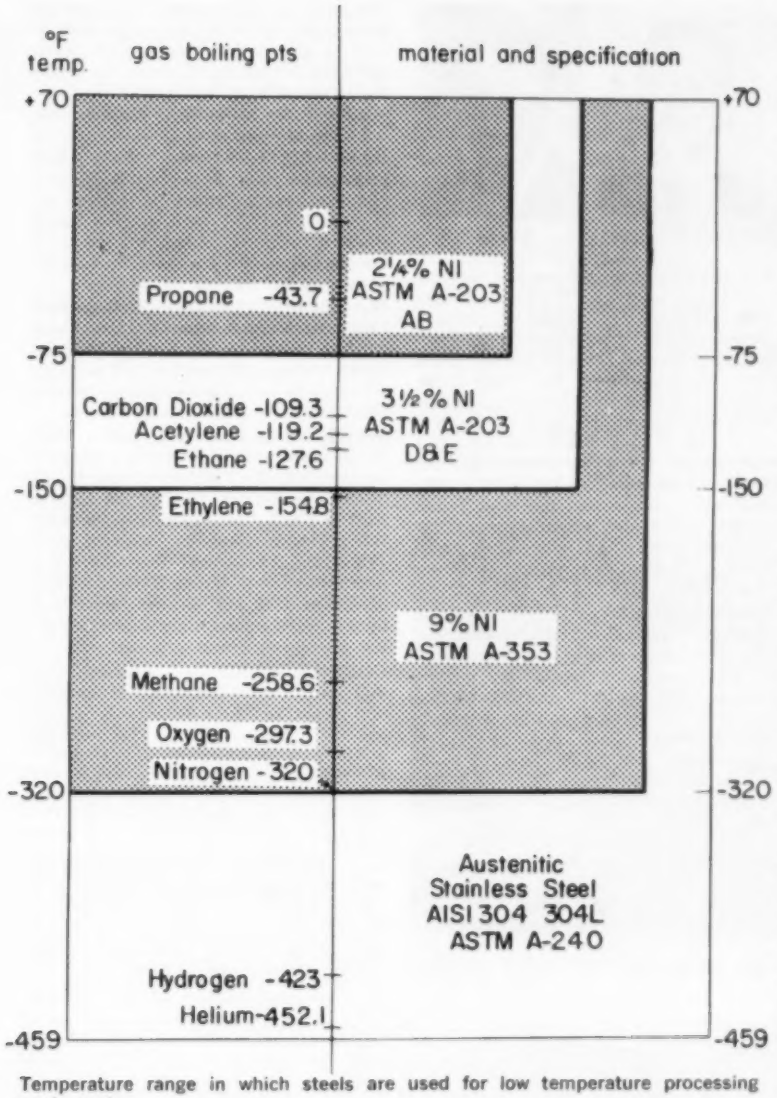
W. S. MOUNCE—International Nickel Co., New York: On the materials of construction and methods of construction from a safety and operating standpoint, designers of the equipment must make the basic decisions and apply materials properly. Any necessary maintenance or repair work must be done without disturbing the properties of the material in the original construction; assuming it has been properly chosen and is behaving properly in the first place. The quickest way to cover a lot of territory in little time would be to review briefly the common materials of construction, the reasons for their use, and some limitations from a safety standpoint.

Strength is a prime consideration of the plant designer. Thermal properties, and fabricating characteristics are important. Resistance to brittle fracture is a consideration. Copper, an early and still important material, has low design stresses and good thermal characteristics, but joints must be made either mechanically, or by soldering or brazing. In large structures each method introduces problems and opportunities for leaks and difficulty in operation. Bronze gives a slightly higher design stress and the copper-nickel alloys ranging from 10% to 30% nickel show substantial gains in design stress. These copper nickels are now produced in weldable grades and welding rods are available so that you can consider welded joints. Monel has applications, not so much in air separation plants, but in some other liquefied gas plants where corrosion problems are involved, specifically fluorine. Aluminum has come in strongly recently, in air plants. Relatively pure aluminum has a low design stress but the newer alloys, which are solid-solution hardened, basically, the magnesium manganese alloys, have good design strength. Considered on a strength-weight-cost basis, they show good economy. The main problem associated with the aluminum alloys are their welding characteristics. Aluminum alloys offer problems from a corrosion standpoint in specific instances, and finely-divided metal may get into the system through repair procedures or original assembly and cause an explosion.

Cleanliness requirements in the missile fuel systems are very strict; the corrosion products that may form with aluminum and a steel which is not essentially corrosion resistant impose limitations for such service. Stainless steel, extra low-carbon grade, gives a very desirable design stress and is particularly corrosion resistant. It is weldable, and is increasingly considered for some applications filled previously by copper and aluminum. The cleanliness requirements for missile fuels are now being met in the handling and storage end of the systems, with stainless. Stainless' low thermal con-



In plant construction, equipment designers must make basic decisions and use materials properly. Photo Spencer Chem. Co.



Temperature range in which steels are used for low temperature processing equipment.

ductivity may be a disadvantage in many applications, though in some places it is not. Stainless is expensive, for though it does have a higher strength, it is heavier. Sometimes the price is high because you buy metal by the pound.

ASTM A–353 is 9% nickel steel, a ferritic steel as compared to the austenitic steel 304. It is cheaper than stainless, and has a higher strength. The steel is readily fabricated and welded and work is now going on to develop a better and stronger weld rod so that even larger stress allowances can be used. The material does not have the corrosion resistance of stainless steel. Thermal expansion is low compared with stainless steel, aluminum, and copper. The pressure vessel code now requires that welded 9% nickel steel vessels be stress relieved after welding. However, our work indicates that the low temperature impact requirements can be met in the as-welded condition, and a case will be presented to the ASME Code Committee for consideration. Generally, the ferritic steels or the lower alloy steels may be subject to fracture in a brittle manner under certain temperature and loading conditions.

Table 1. ASME boiler & pressure vessel allowable design stresses

Copper-plate	6,700 psi
Copper-tubing	6,000
Muntz Metal-plate	12,500
Cupro-nickels –90–10	10,000
Cupro-nickels –80–20	10,700
Cupro-nickels –70–30	12,000
Monel-annealed	17,500
Monel stress relieved	21,200
Aluminum–3003–0	3,350
Aluminum alloy–5456–0	10,500
Stainless steel–304	18,750
9% Nickel steel–353A	22,500
9% Nickel steel–353B	23,750

The ASME code and the ASTM specifications have established a system which indicates the temperatures at which these materials are resistant to brittle fracture. We know of no instance where a material conforming fully to the code and to the specifications has failed in a brittle manner in service. In the stainless steels the 304L grade is preferred because it can be welded without danger of carbide precipitation, which might harm the corrosion resistance of the material, or the danger of excessive development of ferrite, which might affect its low temperature toughness. Appropriate rods and practices are well spelled out for most of these materials by the American Welding Soc., the ASME codes, and the ASTM Specs.

LAWRENCE—U.S.I. Chemical: You left two questions in my mind, one was if aluminum corrosion products end up in the main vaporizer will they cause an explosion? Most of our air separation plants have aluminum exchangers, I believe.

MOUNCE—International Nickel: The only instance that I know of was in the storage and handling facility not in the main oxygen plant. This was where an explosion and fire occurred in transferring liquid oxygen from a storage tank to a tank truck which was to take it to a launching pad. They investigated the cause, and as far as they could determine, the repair to the aluminum pipe might have left either flux or powdered metal in the line, and this became heated and burned.

LAWRENCE—U.S.I.: You mean it reacted with the liquid oxygen?

MOUNCE — International Nickel: There was an external source of heat somewhere that heated it up to the point where it actually caught fire.

LAWRENCE—U.S.I.: The other question was on 9% nickel. Is it not used because of the deprecation, otherwise it

Mounce

Davenport

Morain

Putman

would be a good metal for low temperature plants?

MOUNCE—International Nickel: It is being used now. The restricted availability of nickel from 1950 up to about a year ago is the reason why it wasn't used more widely.

LAMOND—Canadian Industries: I wonder if any of the gentlemen here have any idea on tightening of liquid oxygen flanges. We have a problem, especially in the high pressure lines. It seems that no matter how hard we tighten them to effect a leak-tight joint at ambient temperature, the joint may start leaking again when the line is cold. Our only answer to this is to retighten the joints at operating temperature. The system is depressured and a heavy nitrogen purge is provided to keep the oxygen concentration at 21% or below.

ODOM—Chemetron Corp., Searsport, Me.: In cases of leaking flanges we have found that doubling the number of bolts helps. In other words, in a four-hole flange drill out and put in eight bolts. It helps distinctly out of proportion to the number of holes. We also have abandoned Teflon for cold box use. We find that Teflon has a flowing coefficient even at low temperatures and it becomes brittle at the temperatures encountered.

We're using Darcoid, an asbestos-type gasket with somewhat better success. Some time ago, we picked up, I think at one of these meetings, the hint that many people soak their asbestos gaskets in wax or petroleum wax. This seems to help. But we have found that we are unable to prevent the mechanics from oversoaking them. They get too much wax in and while it appears solid when it's cold, the wax squeezes out when the flange is tightened. In self-defense we have discontinued that practice; but doubling the bolt holes in the flange will certainly help tremendously in making these joints tight.

MARTIN—Spencer: This may sound a little ridiculous but I offer it in perfect seriousness. Maybe you can eliminate the flange joint. I think a lot of us lean over backwards to get joints in where we could just as well use a welded joint.

SHANER—Linde: We would consider the tightening of flanges while liquid is in the line an extremely dangerous and hazardous operation. As a precautionary measure, we do not perform any maintenance function on the lines while liquid oxygen is in the lines.

R. L. SWOPE—Southern Oxygen Co., Washington, D. C.: I know the gentlemen from Chemetron stated that they were getting away from Teflon. But we have found that where we have troublesome joints, the Teflon is the one sure cure for them, just to reverse the theory. One of the most recent things that we have found to be very helpful on a particularly troublesome joint, namely a flare-type connection, is Teflon 30; one of the dispersants of powdered Teflon, in a liquid carrier. There is, in this material,

Rogers

Swope

a wetting agent which may not be completely safe in oxygen. We have run tests attempting to fire it under oxygen conditions and if it's permitted to dry thoroughly before oxygen is admitted to the lines we have found that there is no difficulty. One of the interesting applications of this particular liquid Teflon was on a leaking joint which was equipped with a solid Teflon ring gasket. This was in a joint between two halves of a solenoid valve. We coated the solid Teflon gasket with liquid Teflon as we put it back in the valve and tightened the valve body up. We had no further trouble from that source.

ODOM—Chemetron: Just to make this thing fully ridiculous, we have departed from the custom of using so many welded or brazed joints and are putting in more flanges. Such problems in the air plant are illustrated by one recently where one of the soldered joints suddenly popped open about 1¼ in. Obviously the joint wasn't constructed properly in the beginning, otherwise there wouldn't have been such a strain.

We also found that this joint had been brazed with ordinary 50-50 solder instead of silver solder. We then deliberately broke a lot of 50-50 solder joints and resoldered them with silver solder and have had no further trouble. This job was around the hydrocarbon absorber manifold valving section. We had to break several joints before we got back to a place where the flanged joints were available, permitting the lining-up of the whole assembly without strains. The lack of enough flanged joints resulted in considerable delay.

DAVENPORT—Ketona: We've had considerable difficulty with stem packing on our valves. It consistently leaks on us. We tightened it down to the point where we stopped the leak and the valve became inoperable. I wonder if I can get any comments on this?

W. A. MORAIN—Cooper Bessemer Corp., Mt. Vernon, Ohio: We found that braided Teflon is a very good packing for valves on expander engines and in quite a few cases have experienced no trouble whatsoever.

ODOM—Chemetron: We tried a little dodge based upon the Graphlon packing we buy from Air Products for our liquid oxygen pumps. We tried it out on the shaft of a valve which isn't moved often. We put in a couple of layers of solid Teflon sheet first, and then filled the packing box with Graphlon. Then a sheet of Teflon was put on top, good and tight. A pretty good, tight joint that will last a long while was obtained.

GORDON WEIGERS—American Cyanamid Co., New Orleans: We came up with what we think is a fairly simple solution. Packing-wise we use braided asbestos and paraffin, and we find that if the operators just steam the valves, the valve bonnets, so that they are warm before they are operated, we get no leakage.

L. E. PUTMAN—Superior Air Products, Newark, N. J.: In connection with using graphite in a valve stem packing, you can set up an electrolytic corrosion problem, particularly if moisture diffuses inward over a period of time.

Instrumentation application

Changes in atmospheric conditions rather than operating techniques cause changes in the product stream.

SWOPE—Southern Oxygen: Appproximately a year ago, the Navy Department, Bureau of Aeronautics, placed certain very low limits on the permissible amounts of specific hydrocarbons and other contaminants which would be considered acceptable in liquid oxygen. Of principal interest to them was methane, which they originally limited to 5 ppm. (This has since been revised to 25 ppm, and is still in controversy.)

Although our liquid was normally acceptable, several cases of contamination occurred during periods when the atmosphere was approaching a "smog" condition. According to Navy tests, the methane content of the liquid was reported to be as high as 54 ppm on one occasion, and may well have exceeded this value on others. Other contaminants such as CO, CO_2, acetylene, and oxides of nitrogen were reported as remaining within the acceptable limits.

When the Navy originally established

the limits on methane and other contaminants, they set up their own facilities for testing liquid oxygen at key points. Acceptance was based on their tests at the time of delivery or upon qualification tests made at the producing plant subject to acceptance tests at the point of delivery.

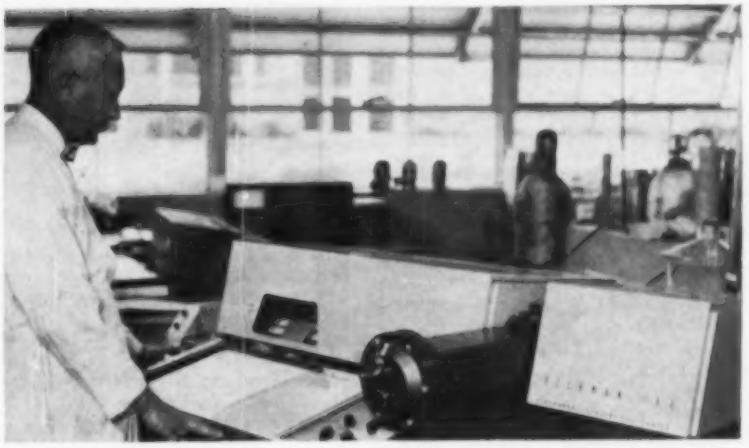
This was fine from their standpoint, but left the supplier in the uncomfortable position of not knowing, in advance of delivery, whether or not his liquid would be accepted. The Navy's original belief was that a plant capable of producing methane-free liquid oxygen on one occasion would always produce methane-free liquid. The fallacy of this theory became apparent almost immediately when it was observed that changes in atmospheric conditions, rather than operating techniques, were responsible for changes in the product stream. The necessity of testing individual shipments became apparent. It appeared that infrared spectrophotometry held the only solution to the problem of analysis. We, therefore, purchased a Beckman IR4 instrument with a 10-meter cell. This is an extremely sensitive and flexible instrument and requires a great deal of experience to operate.

Analyses are now made on all shipments prior to delivery. When it is not being used for the analysis of a specific sample, the instrument is constantly monitoring the methane content of our product. In the event of a methane increase to a predetermined limit, our operators divert the production to a disposal point until the condition clears up, thus avoiding contamination of our storage and transport vessels.

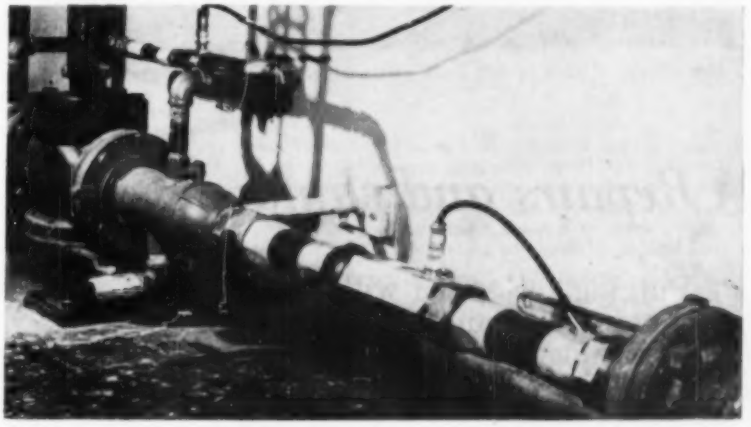
We anticipate that the instrument will be of greatest value to us in helping to correct the methane condition, but it is still too early to report much progress in that direction. Using the IR4, we have learned that the primary source of methane is the atmosphere—there being little or no increase traceable to the breakdown of lubricants. We also find that nearly all of the methane present in the air will finally appear in the liquid oxygen. We have also found that the concentration can be reduced, but only slightly, through the use of adsorbents and molecular sieves located in the liquid oxygen stream. Our current thinking is that methane can probably be more easily eliminated from the high pressure air feed.

L. MALEY—Mine Safety Appliances Co., Pittsburgh: We have built several analyzers, liquid oxygen vaporizers, and continuous analyzers for acetylene in liquid oxygen and have installed them in several plants. Quite frankly, we are experiencing difficulty with them in getting the volume of sample required to obtain a good analysis of acetylene in the liquid oxygen.

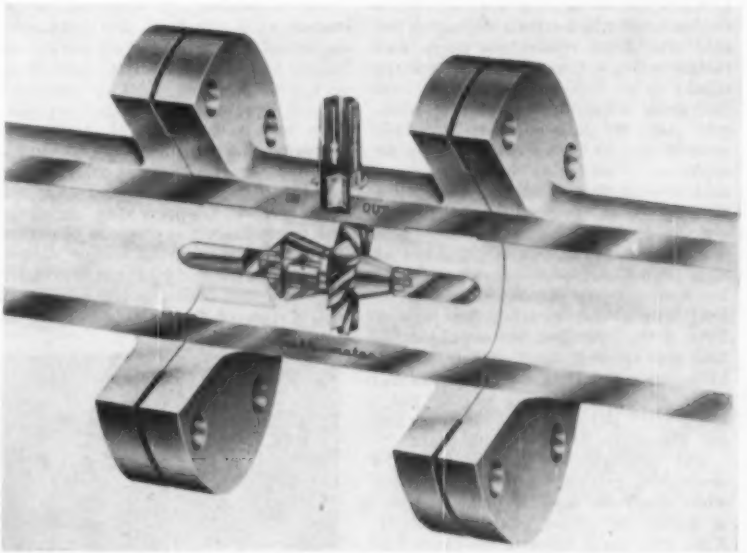
Consequently we have pulled back some of the analyzers and are continuing work to develop a continuous acetylene analyzer and vaporizer. We have found that most of our difficulties were in ma-



Infrared spectrophotometry is used as a means of analyzing product oxygen for methane content. Photo courtesy Beckman instruments.



Turbine meters are finding use in liquid oxygen installations. Photo courtesy Fischer & Porter.



Cutaway view shows principle of turbine meter operation. Photo Bowser, Inc.

terials of construction and design. I would like to ask you people here what your reaction would be to an analyzer that would give a reading once every 30 minutes, or once every hour, automatically. The vaporizers that we originally set up were designed to operate on a 6-minute cycle; 3 minutes on one chamber and 3 minutes on another chamber. What speed or time requirements would you set down for the analysis of acetylene in liquid oxygen?

LAWRENCE—U. S. I.: Our feeling at Tuscola is that an analysis every half hour or hour would be better than present practice.

P. O. McELROY—Wyandotte Chemicals Corp., Geismar, La.: Detection of acetylene in our liquid oxygen has always given us a problem because of the apparent low concentrations. On a go or no-go basis, we have adopted the NBS method described in *Analytical Chemistry*, Jan., 1959. In essence, the method is: 2.5 l. liquid oxygen are passed

Maley McElroy

through a 10-mm tube conttaining 3 in. of 3x8-mesh silica gel, the tube is flushed with pure nitrogen until room temperature is reached, a few ml of recommended indicator are sprayed on the gel; a pink or red tinting of gel indicates acetylene present. Negative test indicates less than 1 ppb acetylene.

BUTIKOFER—Standard Oil: I want to ask a question about the turbine flow meters. Can you give us a more detailed description of what you are using?

HIMMELBERGER—Air Products: We use turbine meters in streams with diameters on the order of 1½ to 2 in. Bearing maintenance problems in smaller lines have suggested that bearing friction will require some consideration with regard to safety. We found that a bypass located close to the meters, permitting slower cool-down has reduced bearing problems. A fire in a system at Cape Canaveral was probably caused by a turbine meter, designed for liquid flow, being used in a precooling service, where gaseous flow at high velocities passed through the meter in a reverse direction. However, I think the turbine meter is perfectly satisfactory for liquid oxygen service, if a little judgment is used in its installation and use.

K. A. ROGERS—Liquid Carbonic, Chicago: We've been testing turbine type meters (Fisher & Porter) for about three years and found them, in general, much more satisfactory than positive displacement. We found them the next best thing to weighing the trucks.

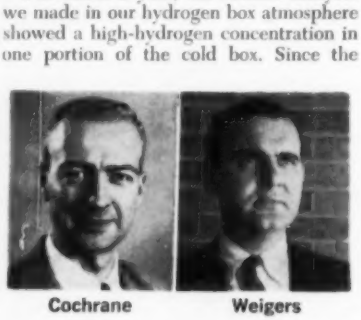
Repairs and shutdowns

Purging rock wool with nitrogen on shutdown is not the complete answer to making the rock wool safe. Pockets may remain.

COCHRANE—Sun Oil: I would like to discuss briefly the methods of purging the cold box before repairs are made, and the method which Sun Oil used to make repairs in its hydrogen purification cold box under a complete blanket of nitrogen. There are three requirements which must be met to have a detonation, or an explosion. Fuel must be present, an oxidant must be present, and there must be a source of ignition. In digging into a cavity in the insulation of a hydrogen-purification cold box, it is possible that these three conditions may be met unless special safety precautions are taken. Fuel will almost certainly be present. Even if the hydrogen box is purged before it is opened, small pockets of high hydrogen concentration will remain. Because of the channeling of the purge gas through the rock wool, these pockets are almost impossible to eliminate.

The possibility of oxygen from the atmosphere getting into the cavity, either while the rock wool is being removed or during the repairs, is also very likely. Even with purge hoses in the cavity and a tarpaulin over the opening it is difficult, if not impossible, to keep the oxygen content at a safe level. We have never succeeded in keeping the oxygen content below 17%. Finally, there must be a source of ignition. This is the most difficult requirement to eliminate, since there are so many possible sources. In preparing to do maintenance work inside our hydrogen purification cold box, we decided that the easiest, and most reliable, method of preventing detonation was to eliminate the presence of oxygen.

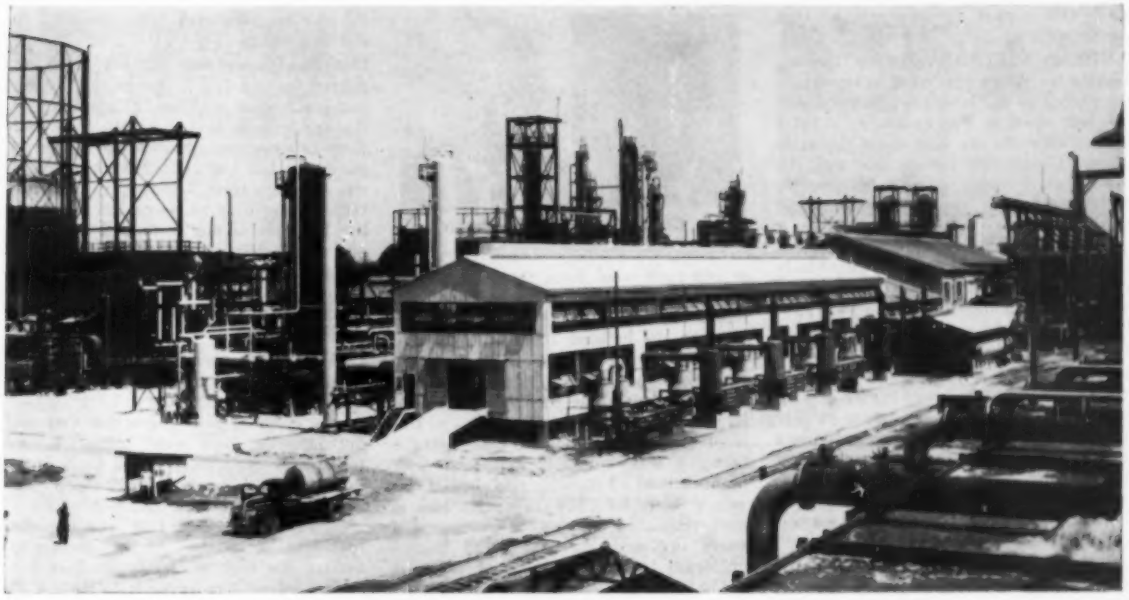
For about a year, the routine analyses we made in our hydrogen box atmosphere showed a high-hydrogen concentration in one portion of the cold box. Since the concentration was localized, it indicated a small leak. However, one day a large frost spot developed on the side of the cold box, indicating that the leak had suddenly gotten worse. The exchanger nearest the frost spot was taken out of service, and consequently the frost spot disappeared. We continued to run the plant at reduced capacity, using only the remaining exchangers. A hole was cut in the side of the cold box, and the insulation was removed in the presence of nitrogen from purge hoses. The minimum oxygen concentration which we were able to maintain in the cavity was 17%.



Cochrane Weigers

The 3 in.-copper pipe in which the leak developed normally contains a 95%-hydrogen stream, at about 350-pounds pressure, and −100 to −130°F. Off this pipe is a 1-in. stainless steel pipe running to a safety valve located outside the cold box. A small pin hole developed in the 1 in.-stainless steel pipe allowing the 350-pound hydrogen to leak out, impinging on the 3-in. copper pipe. This had apparently been going on for about a year; the leaking hydrogen churned up the rock wool in the vicinity of the large copper pipe, grinding the surface. Eventually the copper pipe became so thin that it ruptured. It was only then that we noticed the large frost spot on the outside of the cold box.

Our maintenance people decided not to replace the damaged pipe, but to design a Tee-shaped clamp which would completely enclose the area of the leak. While one of the workmen was removing additional insulation to make some measurements, he saw small glowing particles in the rock wool he was removing. Until a decision could be reached on how to proceed with the repair, the rock wool insulation was replaced in the



Many advances have been made in air separation plant technology, but common sense must still be used in repairs and shutdowns. Photo courtesy Commercial Solvents Corp.

cavity, a tarpaulin was placed over it, and a nitrogen purge hose was placed behind the tarpaulin.

The presence of the glowing particles was very puzzling. It was found that when a nitrogen stream was directed at the particles, the glowing stopped. However, when the nitrogen stream was removed, the glowing resumed. This indicated that oxygen was necessary for the glowing to occur. The rock wool in the area of the leak had been in a reducing atmosphere for about a year, subjected to temperatures ranging from −130°F during normal operation, to about +100°F during the twice-weekly defrosts. During this period some of the iron inherent in rock wool may have been reduced to a pyrophoric state. When the insulation was exposed to atmospheric oxygen as the insulation was removed, the pyrophoric iron glowed.

This is merely a theory which we were not able to substantiate in the laboratory. Some of our people thought that certain particles in the rock wool were heated to red heat by catalyzing an exothermic oxidation reaction. This also could not be substantiated in the laboratory. Efforts were made to produce pyrophoric iron in insulation in the laboratory, but with no success. Rock wool from the hydrogen cold box was placed in a hydrogen atmosphere at about 850 to 900°F. After purging, the rock wool was exposed to oxygen, but no glowing occurred.

Because of the presence of glowing particles it was imperative that the repairs be made under a complete blanket of nitrogen, with the hydrogen box shut down. To insure an adequate nitrogen blanket a special enclosure was constructed around the hole. The enclosure was made as gas-tight as possible. A 6-in. hose carried purge nitrogen into the enclosure. Sample lines from three points inside the enclosure were run outside so the atmosphere could be tested frequently for oxygen content. The oxygen content was kept below 1% inside the enclosure, requiring the workmen in the enclosure to wear fresh-air masks. During the repairs no glowing particles were observed, even when insulation was removed from the enclosure. The leak was successfully repaired and the unit was put back in operation.

LAWRENCE—U. S. I.: I have two contradictory questions. The first is: Did he consider the possibility that the copper that he sloughed off in fine particles could have oxidized to copper oxide or copper carbonate? The second is: Forgetting about the copper—was the insulation higher in iron—maybe this is a general question—is there any color specification on the insulation? I ask that question because we're thinking of changing insulation, and the insulation we contemplate is higher in iron, and is also a little darker colored. But, otherwise, on hydrocarbons and K-value it conforms with what we've been using.

COCHRANE—Sun Oil: I don't know what the iron content of our insulation is. I do know that all rock wool does have iron in it. I don't know if ours is higher or lower than what would be considered average. On the other question about the copper—we had not considered that these particles could have been copper, but this might be a possible explanation.

Lawrence

Nielsen

WEIGERS—American Cyanamid: In an analysis we made—an emission spectrograph of the insulation in the vicinity of our cavity—the iron content was 0.55%. I don't know if that's high or low, or in-between.

HIMMELBERGER—Air Products: The Kirk-Othmer Chemical Engineering Encyclopedia, Vol. 9, p. 122, gives analyses of typical rock wools. Rock wool from Pennsylvaina blast furnaces differs from that from Ohio blast furnaces; but all of them contain metallic material such as iron oxide and magnesium oxide which may run well above 0.5%.

Another comment was made about the oil content in rock wool. The manufacturers prefer to add some oil to minimize the dusting in manufacture. Rock wool in the U. S. generally runs below 0.3% oil. Experimental tests have been run to determine whether quantities of oil, on the order of 0.3 to 0.5%, could be explosive, without allowing for any leaching or any change in content due to temperature change, or temperature cycling. About 4% oil was needed in rock wool for an explosion to occur in contact with liquid oxygen.

MASON—Dow: I wonder if an analogy might be drawn between the wearing away of copper under an extremely reducing atmosphere and the wearing away of carbon packing in argon or nitrogen pumps under low-oxygen concentration; where you get, apparently, unsatisfied bonds of the molecules. This might have

made this copper pyrophoric from that standpoint.

ANDERS NIELSEN—Haldor Topsoe, Denmark: When you tried to reproduce the events in the laboratory you reduced the rock wool at 800 to 900°F. What I had in mind to say was about the same as Mr. Mason only in this case with the iron. I don't know whether it's possible to reduce at the temperatures you have in the cold box. But, if it is possible, it certainly would be a completely different type of iron, and probably extremely pyrophoric. At 800 to 900°F, pure iron would have enough mobility to form fairly large crystals.

COCHRANE—Sun Oil: Are you saying that it was not a fair test—that it is not comparable to try to speed up the process in the laboratory by going to higher temperatures? If the reduction took place in the period of a year at a much lower temperature, say, around 100 or 150°F, which we had in that vicinity during the defrost, this would give us an entirely different and more pyrophoric iron?

NIELSEN—Topsoe: Yes, that's right. I don't know whether it's possible, but if it is, it would give a different iron. This could very well have been pyrophoric iron.

BUTIKOFER—Standard Oil: During a recent strike the Calumet plant was down for about 21 days. The nitrogen wash box vessels were warmed to about 150°F and thoroughly purged with nitrogen. While the box stood idle the equipment inside the box cooled to −100°F by virtue of the refrigeration stored in the insulation. The atmosphere inside the box became flammable, and had a rather high hydrogen concentration. Nitrogen was obtained to purge the box and the interior of the box was checked three times a day for hydrocarbons.

As time went on the molecular weight of the hydrocarbons in the box increased. It wasn't until about the end of the 21-day period that the hydrocarbons were predominantly propane. This showed that the insulation was weathering due to the purging effect of the nitrogen. We are now concerned about how to remove the insulation from the box safely during a shutdown without going into a long purging period.

LAWRENCE—U. S. I.: We took all the insulation out of our box last year to do some repairs. What we did was to increase the nitrogen purge to a very high rate, and then—instead of worrying about hydrocarbons—we worried about the guys breathing. We kept the oxygen concentration down around 10%, except in big openings. Any hydrocarbons that are in there (they're heavy) seem to accumulate down on the floor level. Once you get them out you're in pretty good shape. Of course it sounds wrong to take the floor out before you work up above, but we had a lot of ice up above and it took us longer to get out. And once we removed the insulation from the bottom we didn't have any hydrocarbons to speak of.

WALTON—Atlantic: We removed all

Culp Butikofer

of our rock wool from the cold box. It was a nasty job because we had a distillate leak in the cold box and the rock wool on the bottom, about a foot above the floor in some locations, was pretty well saturated. Our approach was to ventilate as much as possible and to take large panels off the side because this wool (about 12 to 18-in. thick on the bottom) was not only saturated with hydrocarbons, but was also bound together with ice. We kept the box as well ventilated as possible so that if a spark occurred there wouldn't be an enclosure to generate a lot of pressure.

Originally, our rock wool was bought on a low-bid basis and was grey and black. That was the wool which we removed this first time. In many places there were icebergs and accumulations. Later we bought Johns-Manville Spintex. It's quite white. It handles easier and doesn't cause as much difficulty when blowing it in. We also found that this material is much easier to remove than the darker color rock wool we used in the beginning.

ODOM—Chemetron: Not long after we started up, we had to purge our hydrogen-purification cold box. The purging of the box took us nine days. We have had three other occasions when we wanted to purge the box but did not want to spend the necessary time. The penalty of taking such a long time to purge the box with the facilities at our command has been one of the big deterrents to getting the box in better shape. How long did it take Sun Oil to purge their box? Do you have some secret which would enable us to do it quicker?

COCHRANE—Sun Oil: When you talk about purging a hydrogen purification cold box, it depends to a large degree on the quantity of nitrogen that you can put into the rock wool insulation. As we are set up, we can put a fairly large quantity of nitrogen purge into our hydrogen purification cold box.

However, we feel that purging the rock wool is not the complete answer to making the rock wool safe. Pockets will remain where it is possible to have high concentrations of hydrogen or hydrocarbons, because in purging rock wool you get too much channeling. The nitrogen follows the path of least resistance up the side of the cold box and out to the atmosphere. There can be areas in the cold box which will have pockets in which the presence of oxygen could possibly form an explosive mixture.

Hydrogen production

Gaseous hydrogen presents the greatest fire and explosion hazard of any gas because of its wide flammability limits.

MARTIN—Spencer Chemical: There are from 5 to (at least) 14 methods of producing hydrogen in commercial use in the world today. The number of commercial hydrogen purification systems is not as great. The type of hydrogen production system used, and other economic factors, have some effect on which purification systems are used. CO_2 removal is accomplished commercially by scrubbing with monoethanolamine (MEA), diethanolamine (DEA), caustic, water, or hot potassium carbonate. Final traces may be taken out by copper-liquor scrubbing, solid adsorbents such as alumina, and freezing. CO, in small quantities, can be removed by copper-liquor solutions, liquid nitrogen scrubbing, and/or the use of a methanating converter, wherein the CO is reacted with some of the hydrogen present to form methane and water.

There are some hazards common to all of these processes. Gaseous hydrogen, because of its wide flammability limits, presents the greatest fire and explosion hazard of any gas. Carbon monoxide is a particularly dangerous material. It is flammable, has no odor, and has high toxicity. It is always present in highly lethal concentrations in any hydrogen production and purification processes which start with a hydrocarbon raw material. Most of the combinations of

hydrogen production and purification in use today, at some point, involve relatively high temperatures, compared to other chemical processing, and these require special safety precautions.

In those processes utilizing a controlled oxidation between hydrocarbons and oxygen, the reactions can become uncontrolled, resulting in severe damage. The low temperatures involved in nitrogen washing offer hazards of a type which are sometimes unfamiliar. In the first few months of our Vicksburg, Mississippi operation, we ruptured a 6-in. carbon steel line which released a considerable amount of hydrogen into the atmosphere, by subjecting this line to temperatures below −100°F. We were fortunate that damage was restricted to this line and there were no injuries.

Martin

Maune

Ammonia plant compressors

Valves and gaskets are critical; inspection and testing schedules an enigma.

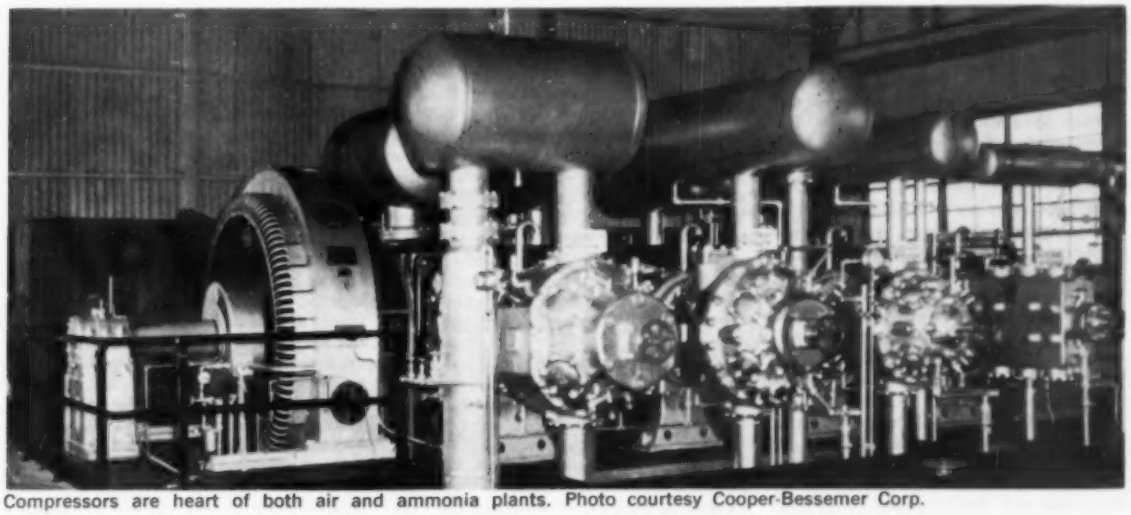
H. E. MAUNE—Armour Agricultural Chemical Co., Crystal City, Mo.: My comments concern our particular plant at Selma, Missouri. We'll start first with the air compressors. In the past we've had some difficulty with fires. We do use synthetic lubricants. In the third stage of our air compressor which is at 650-lb. pressure, we did have some trouble in the earlier days, but we changed the valve design. We are now using circular-channel type valves with which we have no difficulty. They will stay in service under these conditions for a year or more.

Going along to another service where we did have trouble, we compress nitrogen from approximately 1½ lb./sq. in. ga. to 325 lb. in two stages. Our second stage discharge temperature is quite high—about 390°F. We experienced some difficulty with carbon formation in the valves. We can manage to operate nearly a year under these conditions without any serious difficulty. However, we had an experience and didn't know that we were in trouble from carbon formation in the valves. Of course, when our air plant is not producing pure nitrogen, we must take in a little air through the nitrogen cylinders to balance out the load on the gas engine. We can't allow too much air to get through or let the discharge pressure go too high, because hydrocarbon oils are used in this particular service. While it's all right (when using nitrogen during normal operation) to take the machine down for some reason, and put the nitrogen service on air, a fire could develop. We did have a fire in the cylinder and in the pipe line. It cleaned the carbon out for us without any serious damage resulting from it.

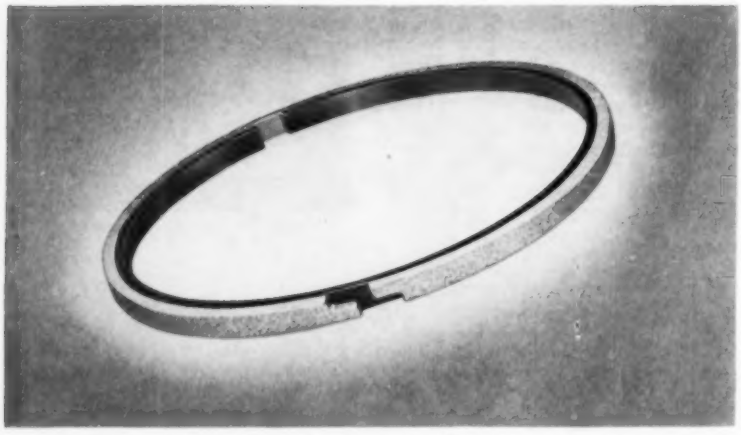
In another service, synthesis gas compressors on our high-stage cylinder were compressing hydrogen and nitrogen from approximately 4000 to 9000 lb., in a double-acting cylinder. We experienced some valve difficulty in our earlier days when we had disc type valves. We changed to channel valves in this service, chrome-plated valves with circular channels. It's the best we have seen. I don't think they will ever wear out, nor break, nor do anything else; which is really what we are looking for.

We had an experience one time on this service when the valve actually came apart. The bolt that holds the seat and the guard together worked itself loose and dropped down in the cylinder. Nothing serious happened. When the piston came by it clipped the head of the bolt off and dropped it down into the discharge valve port. But, if a longer piece had been broken off, the piston would have pushed it against the head and we could have had serious damage—even the possible loss of life.

BOLLEN—Dow Canada: I'd like to make a comment on channel valves. When we first started our plant we had disc valves in the circulator and the rate of plate breakage was extremely high, usually resulting in a very loud clattering and pounding noise in the machine. Sometimes it sounded like the machine was just about ready to jump off its foundation. We had the compressor manufacturer investigate. We tried increasing clearances and changing springs without too much success.



Compressors are heart of both air and ammonia plants. Photo courtesy Cooper-Bessemer Corp.



Extremely low coefficient of friction of Teflon permits its use as piston ring without lubrication. Photo courtesy France Packing Co.

Eventually we tried the channel valves and since that time we have had almost no valve plate breakage. To my knowledge they are a little less efficient valve than the disc valve, but in some installations they are certainly worthwhile.

MARTIN—Spencer: Two incidents: The Cactus, Texas explosion and a fire that were due to a valve problem. As I recall, the seat ring broke. The suction valve dropped down to the cylinder, went out through the discharge valve, through a let-down valve into a low pressure system, and was traveling with enough speed when it came to a malleable elbow (which shouldn't have been there) it went right through the elbow. That's what triggered the explosion.

An accident that we had another time resulted in a man's arm being lost. We had a procedure for checking leaking valves which involved putting a little bit of rag on a wire and sticking it through a suction valve to determine whether the other valves were leaking. This particular compressor was a steam-driven machine. The man had followed the procedure. But then, just to make sure, he put his arm into the suction valve opening. As he did, the machine turned over and he lost his arm.

STOCKBRIDGE—Southern Nitrogen: I want to ask Mr. Maune about the chrome-plated discs he mentioned. First of all, what stages have you used them in, and are they channel?

MAUNE—Armour Nitrogen: The channel-type valves are used in the third-stage air, which is 650-lb. service. They are used in all four stages of our synthesis gas compressors. The chrome-plated channels are used in the third and fourth stages of our gas compressor. We found that they were not necessary in the two lower stages. Why, I don't know.

FRANK HUNTER—Cooper Bessemer Corp., St. Louis: Some points are raised here that are related to problems in another industry that I've had experience with and they're pretty basic. This was a major oil refinery. In putting valves into a cylinder there is, of course, the problem of tightening. You can put an uneven pressure on your gaskets and cause gasket leakage. But in the refinery that I'm describing, we had some machines in service, and through carelessness, the gasketing surfaces on the valve cages had been damaged, and without refinishing them, the workmen put the cages back into the machine and put the machine back into service. Naturally, they ultimately developed leakage.

Another problem we ran into in this refinery was the reuse of some metal gaskets without annealing. A metal gasket seals with its "softness" and once you have pulled down on the gasket you have hardened it. Unless that gasket is annealed (if it is to be reused at all) it will not serve its purpose.

H. A. SOMMERS—Pennsalt Chemicals, Philadelphia: When we started up the Food Machinery plant at South Charleston, W. Va., some four years ago, we ran into a very unhappy experience with feather valves. The first three stages had feather valves and the last three stages had plate valves. The first stage gave us very little trouble, the second stage gave us a great deal of trouble, and the third stage probably 50% as much as the second stage. There was little trouble with the plate valves in the last three stages which handled substantially the same gas. This was serious because it limited the plant to about two-thirds of its capacity.

At first we thought that, perhaps, the first-stage separator was too small and that water was passing through to the second stage. A much larger separator was installed, but we had the same problem as before. It was finally decided to throw out the feather valves and to use plate valves. There has been no problem since. The peculiarity of the feather valve is that when it breaks, the pieces fly around through the system and can't be found easily. They cause lost time far in excess of the time required to replace the valves themselves.

I would like to ask what procedures are followed when a valve is changed on a compressor handling, say, hydrogen and nitrogen, or hydrogen alone? My experience goes back to about 1925 in this particular plant which I refer to, Olin Mathieson at Niagara Falls. Since no nitrogen was available, we simply opened the compressor, changed the valve, and flushed out the air with hydrogen. That has been going on for some 35 years and nothing has ever happened. Still, it is fundamental that you don't permit air and hydrogen to be in the same place at the same time if it can be avoided.

BUTIKOFER—Standard Oil: We always purge with nitrogen before going into any of our compressors containing an inflammable gas.

JOHN CLAPPERTON — Columbia-Southern Chemical Corp., New Martinsville, W. Va.: We are chlorine producers. Part of our hydrogen comes from mercury-chlorine cells. Last year I brought up the problem of the poisoning of our deoxo catalyst. We've since managed to solve this problem. But about six months after we stopped putting mercury-bearing hydrogen into our ammonia unit, we had a ring failure in the sixth stage of our synthesis gas compressor. At the time we experienced the deoxo trouble, we looked into the first two stages of this compressor, expecting evidence of mercury there and found none. We also looked at the intercooler (or after-cooler of the first stage) which has cupro-nickel tubes, and found no evidence of mercury at that point. So, we were somewhat surprised that this great length of time after we had used mercury in our system, to find disintegration (due to mercury) of bronze rings in our sixth stage.

SOMMERS — Pennsalt Chemicals: There are probably more than half a dozen plants in the country using hydrogen from mercury cells, and there are a whole series of problems associated with using this hydrogen, particularly organic chloride and mercury vapor. The plant I now refer to is the one mentioned before—in Niagara Falls. It obtained its hydrogen from Castner mercury cells and there was no doubt that there was mercury in the gas. Three new primary compressors were installed but somebody forgot that there was mercury in the hydrogen. The second- and third-stage after-coolers had brass tubes and they lasted about 10 days. They were quickly changed to steel tubes.

A real problem that exists in all ammonia plants, is the problem of packings at high pressures. Pennsalt has a plant running at pressures of up to 12,000 pounds and we do not know the full answer to the high pressure packing problem. It may or may not be associated with mercury in the gas, but I think it is. We use a conventional packing with bronze rings; so-called bearium-bronze rings and the service is erratic. Sometimes they last a couple of months and other times they will last ten months

to a year. I have observed the same thing at several other ammonia plants and I'd be interested to know if anyone has really solved the packing problem at pressures in excess of 5000 lb./sq. in.

MAUNE—Armour: Our synthesis pressures are 9000 lb. and we have had little, or no trouble with our high-stage packing on the compressor, or on the circulator. The circulators have original packing cases and rings (for 4 years). They don't leak or get hot, so we leave them alone.

The syn-gas compressor has about three years' service, but we anticipate no difficulty there. We do have a very clean gas—nothing in it but hydrogen and nitrogen. Perhaps that's significant.

SIMMS—Phillips Chemical: In one of our plants where we have gas-engine driven compressors, we instituted a program last year of inspecting by Magnafluxing power rods. In one stage (our low pressure compressor) we have 200 power rods and found it necessary to discard 40 of these; some of them were on the verge of failure.

HENDERSON—Dow Chemical: I have here a Teflon ring which has been in service for 3600 hours with no lubrication. We use this in our circulator, operating at 170 rpm, at about atmospheric temperature, so we don't have the high temperature problem. We also have some France Flur-o-Fran rings in service, and we are installing a France Teflon packing, backed with bronze rings. I have a France Flur-o-Fran history on packing and piston rings, where they've been operated in oxygen, air, and syn-gas, with up to 2 years or 11,000 hrs. service.

MAUNE—Armour: One other important point in safety should include the training of operating and maintenance people. We had one occasion where one operator mistook a pressure discharge line for a steam line. This didn't cause any serious trouble, but it points out the need for better training. Such an error could cause serious trouble.

R. F. GOETTLING—Hooker Chemicals, Tacoma, Wash.: About 5 years ago, we found leaks in two of the 12 banks of coils in our primary condenser. One coil had been serviced six months; the other for 12 months before. All coils had been hydrostatically tested to 7800 lb. six months previously. All failures occurred in the bends subject to the highest operating temperatures and most severe corrosion. Each failure consisted of splits several inches in length. The pipe continued to hold system pressure without rupturing, while the plant was prepared for repairs. The faulty coils were blanked off, and plant operated with the remaining coils.

In the process of blanking off the coil, we were surprised to find that three of the flange bolts were broken completely in two. These had been in the primary manifold flanges. A thorough examination of the samples of the pipe by the laboratory of the tubing suppliers concluded that the failure was due to stress corrosion. To remedy this situation, we sandblasted and painted the pipe, the bends, flanges, and manifolds of the primary condenser with epoxy type paint. We flooded the coils with sprays until no dry spots occurred on the bends. A polyphosphate type of corrosion inhibitor is used in the water which circulates through a cooling tower. Coils installed in the future, of course, will be stress-relieved. The remaining coils have now been in service for five years without developing leaks. During this time, they have been hydrostatically tested once at 5200 lb. Since the condensers appeared to be a weak point in the synthesis system, we are concerned with knowing the life that can be expected from them and the methods of testing that might detect weakness before failures.

MASON—Dow: This stress corrosion is a problem that is peculiar to some specific materials. We had some trouble several years ago with a test piece of stainless steel pipe in a film type intercooler. There was a fine network of cracks in the short piece of pipe. Of course it was replaced immediately with steel pipe. At Dow we now use copper clad steel pipe for intercoolers and have practically eliminated any difficulties with corrosion from the outside. Of course there is no trouble with corrosion from the inside. We have some pipe in those film type coolers that has been in operation since 1937 and looks as good as the day we put it in.

MAUNE—Armour: That's a point that's of great interest to many of us. Just what sort of normal life can you expect from primary condensers? Ours have been in service for approximately five years now, and the only place we're getting leakage is at flanges. The various sections of these coolers are flanged into an inlet and discharge manifold, and we're thinking of cutting out all those flanges and welding.

SOMMERS — Pennsalt Chemicals: External corrosion can be generalized by saying that it exists wherever you have a cooler that comes in contact with water, and, particularly, if it's the type of cooler where you have a "wind and water" line. The kind of corrosion that you get in a coil where you can see it, of course, is not so bad. You take care of it when required, but when the corrosion is internal it is apt to be concentrated in places where you have a condensed liquid. The liquids that are condensed out naturally rest in the bottom of the vessel, or the pipe, and in the course of time, cause corrosion.

Hunter Clapperton

In almost all ammonia plants, particularly plants that are running beyond their normal design capacity, the most hazardous place is probably in the discharge of the converter. There have been at least three examples of this in my experience at different locations, where catalyst dust blown from the converter (where you have the highest possible temperature and the highest velocity) has eroded a bend in the pipe to the point where it was a hazard. This would be a good place to look in almost any plant. This piping usually needs to be replaced after some 5 to 10 years of operation.

ODOM—Chemetron: We use salt-water cascade ammonia condensers. Our condensers were specially built and were unique in design at that time (1956). They are Admiralty-covered steel tubes of all-welded construction. At the time we put them in there were no available performance data. But, we've never had a moment's trouble with them, and a recent Audigauge survey disclosed no dimunition of wall thickness.

WALTON — Atlantic Refining: An extremely important safety problem, with which the industry, to my knowledge, has not come to grips, is the question of hydrostatic testing of high pressure vessels. There's a wide difference of opinion and practice on this. Those of us with a background in the oil industry have a long tradition of hydrostatic-testing our pressure vessels at some regular intervals, so we feel quite strongly about it.

Now, hydrostatic-testing of a converter, for instance, is quite a problem, because it involves considerable shutdown time. And, yet it's also a vessel which is probably one that you'd be most concerned about if it should fail. In our case, we said originally that we would hydrostatic-test our converter after five years service. When we changed catalysts at something less than five years, we talked our inspection people into examining the vessel internally and *not* hydrostatic-testing. But, they told me, "Next time you have that thing down, we're going to hydrostatic-test it, or else!"

As I say, there is a wide difference of opinion. This is a safety device, which has been considered very important for a number of years, and yet we don't really seem to have a meeting of the minds on it in the ammonia industry.

SOMMERS—Pennsalt Chemicals: I think the basic reason for testing something is to find out whether it will stand the test—whether things have happened in the intervening years to make its continued operation questionable. In the early days of the ammonia industry, everyone was much concerned about whether or not he had a good pressure vessel because, in those days you didn't always get them. And then, too, you didn't know the effects of hydrogen on the embrittlement of steel and of the possible nitriding effect. By now a con-

siderable backlog of information has been built up which affects the decision to test or not to test.

The first converters that I ever had anything to do with were eventually sold to the Great Western Electro Chemical Company out at Pittsburg, California, and I learned several years ago what eventually happened to them. After being in continuous service for at least 15 years, they were cut open and found to be as good as the day they were made. I think if you can apply that experience to other converters, there's not much point in testing them.

The other components of an ammonia plant, the collectors and oil filters and whatnot, are probably even less likely to deteriorate with age. But there is, of course, always the annoying feeling that maybe you didn't have a good vessel in the first place, and that over the years an incipient crack might become a dangerous one.

Ammonia storage

Water is anathema in high pressure ammonia storage tanks, because of ammonia's high rate of water take up.

SIMMS—Phillips Chemical: In the early days of the ammonia business the specifications for storage tanks were essentially copied from the LPG business. The specifications were dictated by vapor pressure considerations. Phillips presently designs and builds high pressure ammonia storage tanks according to the 1956 ASME code, 250 pound W.P. ASME SA-212-70,000 psi steel test per code requirement.

In recent years some stress corrosion cracking has been reported by AAI in A-A storage tanks, particularly field tanks. One step in overcoming this difficulty was the recommendation by AAI that vessels of 36" diameter and larger be stress relieved or furnished with hot formed heads. Phillips has adopted this recommendation as a specification for our storage tanks.

As production facilities have been expanded the supply and demand situation required the storage of larger quantities of A-A in the off-season. Storage of A-A in the typical high pressure tanks is usually not economical. Most all producers have resorted to 1,000-ton to 2,000-ton spheres operating at 30–75 lb./sq. in. ga.

We have considered the possibility of storing A-A at atmospheric pressure. This practice appears to be coming into wider use in LPG business. It has been reported that one of the most progressive ammonia producers is storing A-A in this manner. I am sure we would all be interested in hearing about any actual experience in this type of storage.

The desirability of storing still greater quantities of A-A in the off-season has resulted in the use of large atmospheric pressure cone roof tanks to store the ammonia in the form of aqua. Many of you have recently installed such storage. Phillips has several installations, the largest being a 323,000-barrel tank in the Texas Panhandle. I am not aware of any serious problems with this type of storage although some of us have managed to collapse a ring or bulge the roof on these tanks.

The best type of coating depends upon the type of storage and geographical location. For high pressure storage in areas where weather conditions adversely affect paints, we prefer the following: sandblast to bare metal, apply one coat of Dimetcote, followed by one or two coats of white vinyl paint.

For less severe conditions, we use an epoxy system prime coat of about 5 to 10 mils dry thickness, followed by one coat of either white or aluminum gray paint, cross sprayed. The spheres are usually insulated. We presently use foam glass coated with asphalt weather seal and painted with one coat of asphalt base aluminum paint.

For large aqua tanks, where sweating is a problem, we prefer to coat the sides of the tank about ⅝-in. thick with asphalt mastic, such as No-Korode, followed by one coat of tank white on both top and sides. Where sweating is no problem the Dimetcote and white vinyl or epoxy system may be used. The latter two are more expensive, but also more attractive than the asphalt mastic.

L. A. SWIFT—Consolidated Mining Co., Calgary, Alberta: We have four atmospheric pressure anhydrous ammonia storage tanks. They're 35 feet in diameter, 27 feet high, and 500-ton nominal capacity each. We have had very little trouble with them, although, occasionally when we take one off line, we have cracked the bottom when putting it back in service. It's a tricky business, because when you put the ammonia in it drops its temperature to about −35°C. When a bottom cracks, we dry out the tank, weld a patch over the crack, and start all over again, doing it a little more slowly.

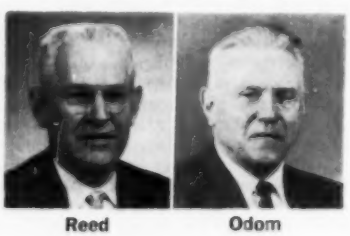
The insulation was originally 8 in. thick in 3 layers of cork, with vapor-barriers between each layer. Those vapor-barriers are probably the most important of all, because they keep moisture from infiltrating the surface of the tank. We did have a certain amount of leakage of moisture down from the top that eventually bulged the insulation off, and we had to replace it on a couple of tanks. When we replace it, we put on 5 in. of fiberglass in 3 layers. We put vapor-barriers in between each layer and it's been a very satisfactory job.

WALTON — Atlanta Refining: Are these carbon steel tanks?

SWIFT—Consolidated Mining: Yes, they're just carbon steel tanks, quarter-inch steel plate.

R. E. REED—Girdler Construction Div., Louisville: In view of the remarks about the tanks, I think a little historical information might be appropriate at this time. I believe that the installation that you just heard of at Consolidated Mining and Smelting was the pioneer installation of that type. There were two atmospheric storage tanks installed in the Havag Plant at Ems, Switzerland somewhat later which also operated very successfully. Those two installations were the only ones that were in existence that we could obtain information about at the time the Southern Nitrogen Plant was being built—being designed in 1955. On the basis of the successful experience

Simms Swift



Reed Odom

Sommers Goettling

that those people had, we decided to take advantage of the savings available in utilizing a large-size atmospheric pressure storage tank for ammonia at the Southern Nitrogen Plant. The particularly attractive economic advantage was that there is a use for the ammonia vapor that is given off from storage and also given off as the ammonia is reduced in temperature, going into storage.

The tank is 7500 tons, nominal capacity, 110 ft. in diam., 40 ft. high, and it's a regular API flat-bottomed, cone-topped tank. The roof is designed for six inches of water pressure. The operating pressure on the tank is approximately 3 in. It has proven to be a simple matter to control the tank and maintain the pressure at 3 in. The system is air-tight and there is no possibility of infiltration. The tank was filled with inert gas before the ammonia was initially put in. A special manifolding system was put in to avoid the differential quick-cooling of the base of the tank during the initial start up. The tank has never been heated up since it was started about three years ago.

The tank is insulated externally with 4-in. Styrofoam insulation with an aluminum vapor barrier. The base of the tank is set upon a pad of insulating concrete, beneath which is an electrical heating coil, used to maintain the temperature beneath the tank above the freezing point. One of the principal differences between this storage tank and the ones at Consolidated that rest upon a gravel fill, is the permanent frost beneath the Consolidated tanks.

Others have used the ground heating technique since, in the large-scale storage of liquid air and liquid methane at atmospheric pressure. In both cases, heating of one type or another below the tanks has been used to avoid the possibility of heaving of the soil. In storing liquid methane or air they have actually had one tank within another to get an absolute vapor barrier. At Southern Nitrogen we relied upon aluminum foil coating to provide a vapor barrier inside the corrugated aluminum covering which is on the tank.

WALTON—Atlantic Refining: Sphere storage usually is built with little corrosion allowance. You have insulation over the steel and a sealing and paint system over the insulation. If the sealer on the outside of the insulation fails and water infiltration results, you can have corrosion. This could lead to a dangerous situation. This has concerned us greatly. We have not been able to keep a paint system satisfactorily on the outside of the sphere for more than 6 months at a time.

Another reason why it is a safety problem is because the paints which are usually considered satisfactory are ones which should be sprayed; and where the spheres are close to the air intake of your air plant, this becomes a problem.

We carefully tested many paints and discovered that the white coat cracks and checks very badly, exposing the seal-coat underneath. Our investigations indicated that the only way to keep a satisfactory white coat on the surface was to reinforce it with glass cloth. This is an expensive proposition, but, if necessary, one that must be done. We found that we must use a glass cloth reinforcement and a vinyl-type paint.

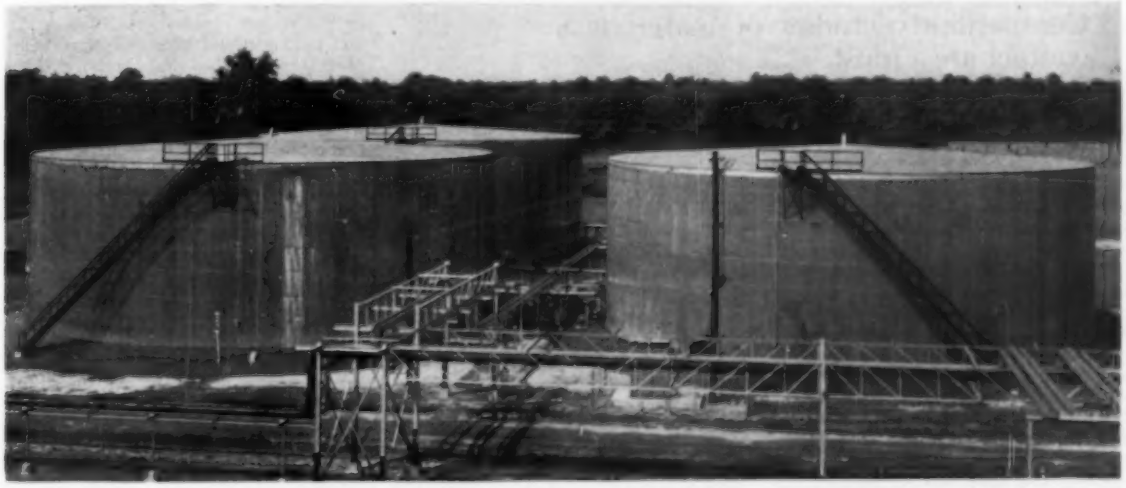
COCHRANE—Sun Oil: We feel that

G. R. Walton Henderson

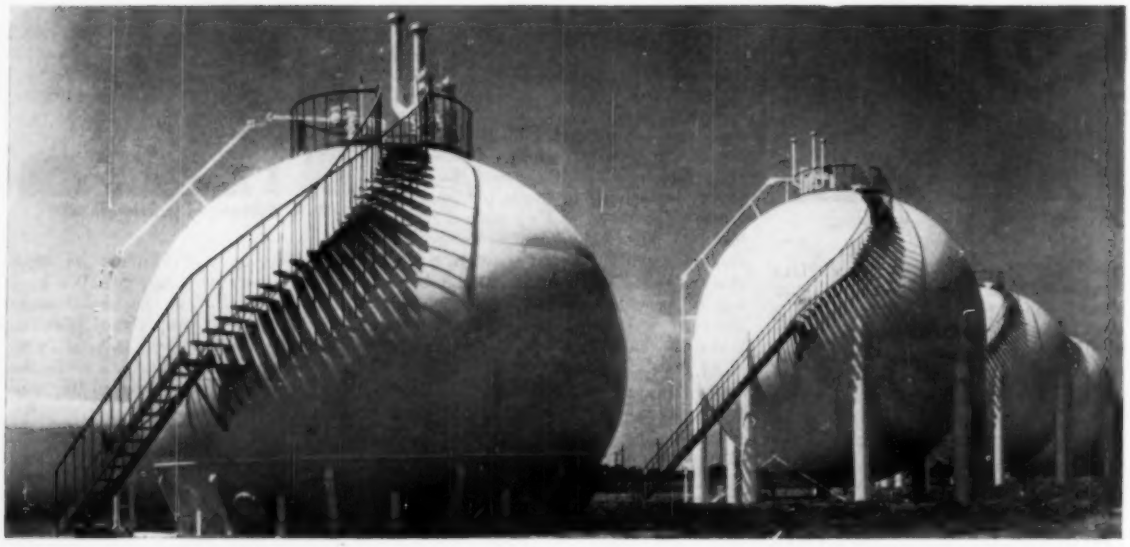
the tank we have is definitely the safest kind of storage you can get. We have what we call bullets; horizontal tanks about 90-ft. long and about 13-ft. in diam. The bullets are covered with coarse gravel or stones which keeps the temperature controlled, even in the summertime, somewhere below 70 degrees. Operating anywhere from 100 to 135 lb. pressure, these tanks have never given us any trouble. We feel that these may be slightly more expensive than spheres, but definitely much safer.

ODOM—Chemetron: A first magnitude safety problem came up with us when the internal level gauge became dislocated from its fastening at the bottom of one of the spheres. We have two 2090-ton spheres and the refastening of that level gauge posed quite a problem. Fortunately, someone recognized the implications of putting water in the sphere, in time, so that we didn't make this mistake. In ammonia tanks one of the principal dangers one must guard against is the terrific solubility of ammonia vapor in water and the hazard of producing a vacuum in these tanks if water is added when the tank is still full of ammonia vapor.

L. B. HENDERSON—Dow: On our sphere, we insulated with Styrofoam, banded on with galvanized iron bands, covered with galvanized chicken wire, over which we put Insul-mastic, and then white paint. After about 4 years, we had cracking, big bubbles of water blisters



Cone roofed tanks, as well as spheres are used for ammonia storage. Photo courtesy Chicago Bridge and Iron Co.



Field tests indicate that the only way to keep a satisfactory white coat on a tank surface is to reinforce it with glass cloth. Photo courtesy National Petro-Chemicals Corporation.

on the tank, and, eventually, a big section peeled off and fell to the ground. At that time we found that the banding and the chicken wire had rusted out and it had to be rebanded. So, what we did, was to reband with stainless steel banding, and a water-base asphalt, in which we embedded Fiberglas cloth, and then covered that with No-Korode Permaseal. Now, we are going to put on aluminum paint over that, when the No-Korode becomes entirely sealed over, and, perhaps next year, we can tell you whether that system will do the job.

R. W. SANDERS—Texaco: On Mr. Walton's points about safety, I think we've missed one, that is, inspection of spheres—hydrostatic testing or pneumatic testing. And, as neophytes in this, we were just wondering what was considered good practice as to test intervals. Our tentative thoughts were hydrostatic at something like 4 to 5 years. Any comments we could get we would certainly appreciate.

L. B. HENDERSON—Dow: We follow I.C.C. regulations of retests for anhydrous ammonia tank cars. This at one and a half times its working pressure after seven years, when it was out of service for repair. We plan to continue at 10-year intervals, unless repair programs make the period shorter.

Materials of construction

Compatibility studies of materials in contact are a must.

G. E. KING—Sohio Chemical Co., Lima, Ohio: We had a fire that could have been prevented by a quick physical inspection, particularly if someone had hung a red tag on a particular valve in which the packing needed replacement. It was on a starting heater (an externally gas-fired vessel in the synthesis area) where the packing started to leak. This should never have happened in the first place, but it did start to leak. It ignited, and then ignited the leak on the bottom of one of the synthesis converters. The heat was so intense that the packing follower holding-bolts actually melted, and extended so that the packing eventually blew out.

The second fire we had was due to a failure of a check valve in a pump discharge. We were having diffculty in circulating MEA into the CO_2 adsorber and not getting the proper flow. Two pumps in the service were running in parallel and the check valve in one of the pumps had lost its flapper in the discharge system. This blocked the flow of liquid. The pump was shut down without knowledge that the flapper was loose in that particular check valve. The hydrogen or synthesis gas backed down through the pump discharge line into the pump and out through the seals and we had a fire.

A physical check is quickly and easily done and prevents subsequent failure. We have used radiological inspection and have gone to the extent of actually photographing the CO_2 scrubber. This is the portion of the MEA system where we had a question in our minds as to whether the trays from the bottom portion of the tower would require clean-up. Corrosion was severe at that point. We took a radiograph through a tray and got all the details—the nuts and bolts all stood out—you could tell what the liquid level was on the tray. Radiological inspection is of considerable value not only for determining whether or not a tray is there, but also because you can find out what is going on in the tower. I have the print of the hairpin bend on the aftercooler in the third stage of our synthesis gas compressors—our high pressure stage at 5000 lb. The X-ray shows a measurable loss. This metal loss is a result of the waterside corrosion.

The corrosion loss on the water side

of the tube can be measured due to the precise location of the film in relation to the radium source used in the radiological equipment. One cobalt and one radium source make measurements to determine corrosion loss in preparation for equipment replacement. This jarred us because we found out that we had used up the corrosion allowance on this particular tube. Even on a physical inspection, we would not have known that we had actually lost that amount of metal from this particular tube.

MARTIN—Spencer Chemical: Here is a picture of a failure of a 6 in. carbon steel elbow which is located in a line between the MEA reboiler and the hot condensate drum. The line carries crude hydrogen which has a high percentage of CO_2. A lot of water has been condensed out of the excess steam from the shift converter. The elbow seemed to have been eroded from the inside until a hole appeared. In this situation, the gas contained water loaded with CO_2. We replaced these elbows with stainless steel and installed a backup jacket. This jacket is a second elbow section on the exterior portion with a small nipple in it. In the event that the elbow lets go, this jacket will contain most of the gas but some hydrogen will come out. A nipple in the jacket serves as an indicator.

BUTIKOFER—Standard Oil: There is a problem in our nitrogen wash box related to materials of construction that has bothered us for quite a while. The exchangers handling the ethylene in the nitrogen wash box have copper coils. The ethylene which we purchase for our cascade refrigeration system contains anywhere from 50 to about 15 ppm of acetylene. We think it is possible for the acetylene to react with the copper to form copper acetylide which can either explode by decomposition of the molecule in the absence of air, forming copper and carbon, or oxidize in the presence of air. We have tried to discuss this with other people whom we thought were experts in the field to determine whether or not we really have a problem. Since we have found no one to commit himself, we have continued to carry out special precautions to wash this equipment prior to doing any work on it. We wash it with a detergent in water solution and then dry it out before we do any mechanical work to that part of the plant. I wonder if any of you can help clarify this situation?

King White

BOLLEN—Dow Canada: Referring to our nitrogen scrub plant explosion about a year and nine months ago: In opening some of the exchangers that weren't too badly damaged by the explosion, but were damaged enough by the fire to warrant their inspection, we found that the tubes in one of the exchangers were perforated in regular intervals throughout their length. In reviewing this with the cold box supplier they were of the opinion that this was caused by the deposit of copper acetylide which had exploded because of the heat. They did not believe this was a possible cause of the explosion, but rather an effect.

D. A. WHITE—Smith-Douglass Co., Inc., Houston: It definitely will blow up. You are right in washing out the equipment. I have seen a terrific explosion with copper acetylide; especially as the NO deposits build up too. That makes a very bad combination.

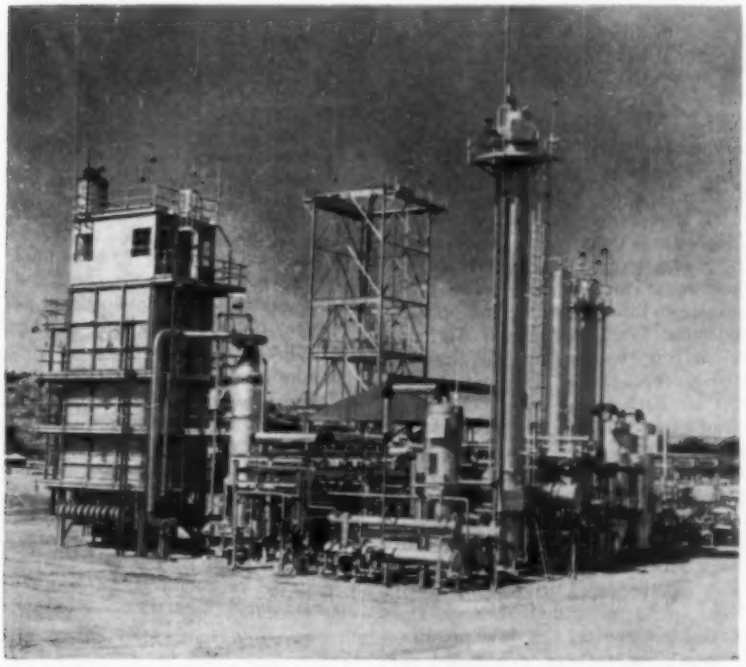
YOUNG—NAS: I hear more and more and more about the use of stainless steels, particularly in oxygen-hydrogen lines. I wonder if the metallurgist is still here who could comment on hydrogen embrittlement of stainless steels?

REED—Girdler: The only comment I could make is that, as I recall, the austenitic stainless steels are not normally subject to hydrogen embrittlement. I believe that it is confined to ferritic and, perhaps, martensitic structures.

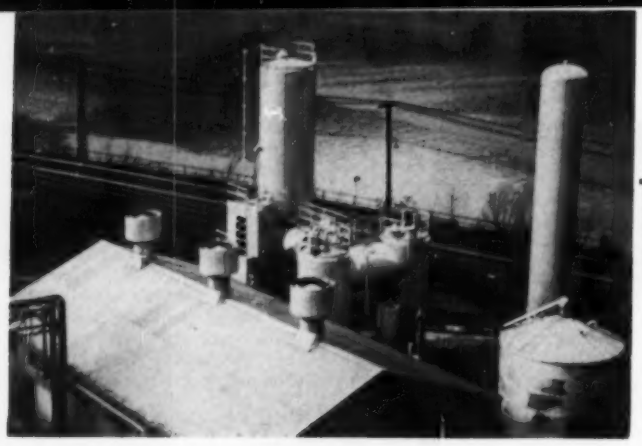
BUTIKOFER—Standard Oil: We had a nitrate explosion which occurred while we were pumping down one of our large nitrate storage tanks, which contained about 90% ammonium nitrate in water solution. We used an overhung impeller pump driven by a 10 hp. motor. The tank was down to about three feet when the pump lost suction. About the same time, the impeller began to rub on the casing, generating heat. This was enough to explode the nitrate. It blew the end off the pump and shoved the shaft back into the motor. Both pump and motor were a complete loss.

It is difficult to develop a safety technique for anticipating such breakdowns because nitrate is a difficult material to instrument. However, we have established the practice of pumping out nitrate tanks with a reciprocating pump where there is a chance of losing suction.

MASON—Dow: There is always some possibility of inspiring air into combustible gas mixtures if the compressor intake pressure drops below atmospheric. Such inspiration of air can be prevented by the proper selection and maintenance of packings, however, an even more effective method of protection is presently being practiced. A Mercoid, or other type of pressure switch, is placed on the inlet line to a compressor and set to operate at a low, but positive, pressure. This switch is connected electrically into the motor circuit to shut the compressor down immediately when the pressure reaches dangerously near atmospheric pressure.



Thermal stress, corrosion resistance, and strength are the prime design factors. Photo courtesy Girdler Construction Division.



View of a typical unattended oxygen plant with capacity of 48 million cu. ft./month.

C. P. Andersen
Linde Company (Union Carbide)

Unattended oxygen plants

Key to safe operation—continuous monitoring of automatic air separation process designed on a fail-to-safe basis.

The unattended plant is defined as one which operates automatically and entirely without operating labor. The building is normally locked to exclude all personnel and the plant is checked weekly or daily depending on the size. The plants have a safety monitoring system which advises a supervisor through a commercial monitoring system if trouble does occur. If the malfunction is serious, a particular piece of equipment or the entire plant will be shut down automatically. Five sizes of unattended plants ranging in capacity from 7 million cu. ft./month to 100 million cu. ft./month have been designed and built. Over thirty of these plants are currently being operated by Linde. The plants are usually located on the customer's property.

The purpose of this article is to present pertinent design features and construction and maintenance practices which have contributed to safe unattended oxygen plant operation. Recognizing the potential hazards associated with gaseous oxygen plants, great emphasis was placed on safety in engineering of these plants. Extensive development work, including two years of pilot plant operation, preceded the installation of the first production unit.

A supervisor is assigned full time to the larger plants and is normally present at the plant 8 hr. a day, 5 days a week. Plants under 40 million cu. ft./month capacity operate completely unattended with weekly service checks which require one man about 6 hr.

Process operation

A low pressure air separation cycle is used in all plants. Refrigeration is supplied by an expansion turbine in the larger size plants and by the addition of liquid oxygen to the column in the small plants. The cycle used in plants of 40 million cu. ft. capacity and larger is shown in Figure 1. Air is compressed to approximately 75 lb./sq. in. gauge pressure and is cooled to liquefaction temperature in one of the regenerators. Dry gaseous oxygen product at atmospheric pressure is withdrawn through regenerator imbedded coils. Waste nitrogen is warmed to ambient temperature in the alternate regenerator. The main cold end air stream and the smaller side bleed air stream from the regenerators are passed through silica gel adsorbers to remove acetylene, heavy or dangerous hydrocarbons, and CO_2. After the gel cleanup, a portion of the cold end air stream is combined with the warmer side bleed air stream to make up the expansion turbine flow. This air is expanded through the turbine and enters the low pressure column. The turbine is a radial inward flow machine loaded with an air blower and operates at 35,000 to 40,000 rev./min. The remaining cold end air is passed to the high pressure column. The rectification equipment consists of the standard high and low pressure column and main condenser. An auxiliary condenser is not used. A liquid phase adsorber is used at the main condenser to remove the trace quantities of acetylene, heavy hydrocarbons, and CO_2 which may have passed through the gas phase gel adsorbers. Liquid oxygen which percolates up through the main condenser during the boiling process is passed through the adsorber and returned to the main condenser liquid sump. The liquid recycles continuously through the gel bed. This adsorber is designed to operate for at least one year without reactivation and has ample safety factor for handling unexpected concentrations of contaminants.

Centrifugal air compressors are used in the larger size plants with capacity control maintained by suction throttling. Two-stage reciprocating air compressors are used on the smaller size plants. Capacity of these machines is controlled by clearance pockets and suction valve unloaders. Oxygen gas is compressed to 150 lb./sq. in gauge in a two-stage reciprocating compressor and is delivered to the customer's pipe-line. During periods of low demand, an additional single stage booster compressor is used to further compress a portion of the oxygen for storage. All compressors are electrically driven.

Storage facilities for gaseous and liquid oxygen are usually provided for use during peak demand and to insure a continuous supply during plant shutdown.

The introductory photograph shows an over-all view of a 48 million cu. ft./month installation including the cold box, gas receivers, insulation storage silo, and compressor building. The cold box consists of three interconnected casings. One casing contains the columns, main condenser, and adsorbers, the other two casings contain the regenerators.

A thorough preventive maintenance program is maintained on all compression equipment to insure safe and efficient operation. Cooling water jackets are flushed periodically to re-

move silt or other obstructions. The valves, connecting rods, and piston rings, etc. are checked periodically to detect any faulty conditions. The petroleum base lubricating oil used in the reciprocating air compressors must meet rigid specifications. The primary requirements are low carbonaceous deposits, low hydrocarbon contamination of the air stream and good lubricating qualities. Special precautions are taken during the erection and operation of the oxygen compressors to insure safe operation. The compressors are normally cleaned at the factory; however, if they are permitted to set idle during extended construction periods, the machines are dismantled to remove any rust and other foreign materials. The oxygen compressors are initially run with air to check for possible hot spots or other malfunctions. The temperature and pressure monitors used to safeguard the compressors are discussed below.

Plant instrumentation

Sufficient instrumentation is provided to operate and control the process, and protect equipment in case of malfunction. All of the process controls are basically pneumatic. The monitoring equipment is essentially electrical. The prime consideration in instrument selection was reliability. The simplest instrument which would perform the desired function reliably was chosen.

Process controls are provided to perform the functions normally carried out by the operators. Typical controls on the cold box components are liquid levels, regenerator side bleed air flow, expansion turbine flow, turbine temperature, product purity, and regenerator reversal. In the larger plants it is necessary to automatically switch and reactivate the side bleed gel adsorbers. Instrumentation is also provided to control the capacity of the air compressor, liquid oxygen storage utilization, gaseous oxygen storage and the oxygen compression system. The instruments are conventional pneumatic recorder-controllers.

The cleanliness and reliability of instrument air supply is important. In these plants the air for operation of instruments and valves is taken from the process stream at a point where it is oil-free, and has a dew point of −150°F. With this ideal supply, problems arising from instrument air supply are negligible.

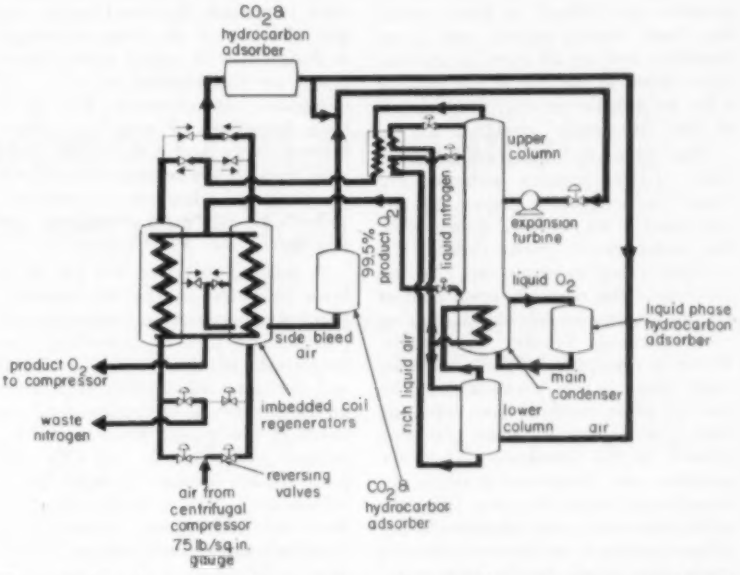


Figure 1. Simple process diagram of an air separation unit for processing 80 million cu. ft./month of oxygen.

Monitoring system

Process monitors, the key to an unattended plant, are provided for items which would normally be observed by the operator. The monitoring system is separate and independent from the process control system. In applying monitors to critical variables which are controlled, it was assumed that a controller with alarm contacts cannot monitor its own control and a separate instrument for this purpose was provided. A typical example of this is the liquid level monitor on the oxygen side of the main condenser. Primary sensing elements for pressure switches are bellows or diaphragms. Elements for temperature switches used for ambient or higher temperatures are normally based on the expansion of a liquid in a closed system. Resistance thermometers are used in the low temperature process.

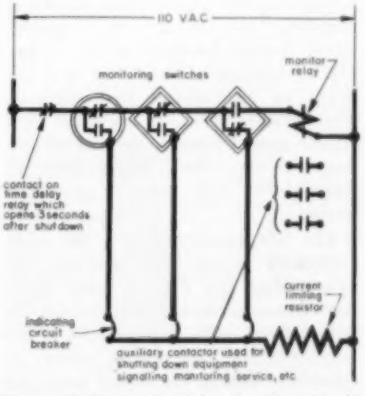

110 V.A.C.
monitoring switches
monitor relay
contact on time delay relay which opens 3 seconds after shutdown
current limiting resistor
indicating circuit breaker
auxiliary contactor used for shutting down equipment signaling monitoring service, etc

Figure 2. Typical safety monitor circuit used for safe operation of unattended oxygen plant.

The primary variables that are monitored in the cold box portion of the cycle are high and low liquid level in the main condenser, product purity, regenerator or reversing heat exchanger reversal, and bursting disk temperatures. Several monitors are required on the side bleed adsorber reactivation system. Items monitored on the expansion turbine include oil pressure and temperature, bearing temperature, high and low speed, and high and low discharge temperature. Items that are normally monitored on the compression equipment are common cooling water pressure, oil pressure, interstage and discharge temperatures, high and low discharge pressure and bearing temperatures on compressors, motors and gear boxes. The standard overload protection is provided on all electric motors. On the larger plants monitors are provided for as many as 80 items.

A simple monitor circuit is shown in Figure 2. Each of the monitor

switches has a normally open and normally closed contact. When a switch actuates, these contacts simultaneously reverse. The normally closed contacts are defined as those which are closed during normal, safe plant operation and are all wired in a series-type circuit to the coil of the monitor relay to provide an energized circuit of the "fail-to-safe" design.

The normally open contacts on each of the monitor switches are wired to a separate indicating circuit breaker. In case of a malfunction, the series circuit opens causing the monitor relay to drop out. At the same time the normally open contact on the monitor switch closes, causing the indicating breaker to actuate. Power is disrupted by the time delay relay after a few seconds delay to prevent other breakers from actuating due to secondary abnormal condition caused by the shutdown. When the monitor relay drops out it opens the compressor motor start-stop circuit to affect the compressor shutdown. Additional contacts on the monitor relay open the circuit to the commercial monitoring service causing a signal to be transmitted and lights a pilot light to indicate which equipment has been shut down.

All indicating circuit breakers in the monitor circuit are mounted in a panel to provide visual indications of actuation. This panel contains 76 breakers or annunciators and is used on an 80 million cu.ft. per month plant. To explain the operation of the panel, suppose the plant had been shut down due to high discharge temperature on an oxygen compressor. Upon arrival at the plant, the supervisor would find indicator No. 856 actuated and the base load oxygen compressor circuit pilot light glowing bright. The difficulty is therefore clearly indicated. Upon restarting the plant, it is necessary to by-pass certain of the monitors until the plant is running normally. The by-pass pilot light glows brightly when a by-pass is actuated and if the supervisor does not acknowledge an audible alarm every twenty minutes by pressing the by-pass reset, the by-pass will be automatically nullified. This prevents the plant from being improperly monitored if the supervisor should become careless.

Chemical analysis

Instrumentation is not provided for continuous analysis of the main condenser liquid for dangerous contaminants. An Ilosvay acetylene test and total hydrocarbon analysis is run by the plant supervisor on a weekly basis. Visual inspection of a liquid sample is made daily when the supervisor is present. As stated earlier, the gel adsorber at the main condenser is designed with ample safety factor based on the removal of CO_2 and dangerous contaminants. The small trace quantities of acetylene, heavy hydrocarbons and CO_2 which may pass through the regenerator and the gas phase gel adsorbers are easily adsorbed in the main condenser gel adsorber.

A positive acetylene test has never been indicated in the 80 operating years of experience on the unattended plants. The total hydrocarbon concentration of the condenser liquid will fluctuate only slightly depending on the quantity of methane and ethane entering the plant. Since acetylene, heavier hydrocarbons and CO_2 will preferentially displace the light, highly soluble hydrocarbons in the adsorbers, the total hydrocarbon concentration is entirely the lighter fractions, namely

C. P. Andersen is project engineer in the Engineering Laboratory at the Linde Company, Tonawanda, New York. He joined Linde in 1953, and has worked on various phases of air separation plant design. His work has also taken in field assistance in plant operation. Andersen spent two years in the U.S. Army, where he was assigned to the Army Chemical Center in Maryland. A graduate of South Dakota State College, he has a BS in Mechanical Engineering.

methane and ethane. Laboratory analyses of main condenser liquid samples have shown that methane and ethane are the only hydrocarbons present in the liquid. The adsorbers therefore provide a basic inherent safety feature because of their selective adsorption of acetylene and the heavy or less soluble hydrocarbons. The concentration of methane and ethane would have to exceed 4% before reaching their lower limit of flammability and cause a potential hazard.

The CO_2 concentration in the main condenser liquid will normally be appreciably less than 1 ppm. Since acetylene and the heavy hydrocarbons will preferentially displace CO_2 in the adsorbers, the CO_2 would exceed its solubility limit in the liquid and form a cloudy solution before reaching a dangerous concentration of heavy or less soluble hydrocarbons in the condenser liquid. However, this condition has never occurred in any of the plants.

All plants are thawed on a yearly schedule.

In conclusion, the important features that contribute to safe unattended plant operation are:

1. Use of a simple low pressure process cycle.
2. Maximum use of silica gel to remove dangerous contaminants such as acetylene from the process streams and not just control them to a supposedly safe level.
3. A complete thaw of the plant annually.
4. The design of all process equipment monitor devices on a fail-to-safe basis.
5. Thorough cleaning of all equipment to remove any foreign materials and the selection of safe materials.
6. A thorough preventative maintenance program to keep all mechanical equipment, process equipment, and instrumentation in top operating condition.

Discussion

COCHRANE—Sun Oil: Does part of your safety procedure include blowing down any liquid from your reboiler, either continuously or intermittently?

ANDERSEN—Linde: We do not rely at all on drainage. In fact we have never drained this type of plant. We rely entirely upon the silica gel to remove the contaminants. The silica gel adsorber in the main condenser is actually required to remove only a very small quantity of the impurities. Most of them are removed in the gas phase adsorbers.

WALTON—Atlantic: Is there any duplication of your instrumentation for emergency shut down? The reason I ask this is that there are occasions where we have instrument failures which are completely unpredictable. How can you be confident that when you have a failure (a mechanical failure, a bearing failure, or something like that) your instrument is going to truly detect it; that it won't, at that unfortunate time, give a false signal, or no signal at all? The second part of the question is do you have temperature-monitoring on compressor packing?

ANDERSEN—Linde: In answer to the first question, in all cases we apply the monitors on a fail-to-safe basis so that if the monitor, or instrument itself, should fail, it will cause a shut down. The greatest portion of the shut downs are actually caused by the malfunction of a monitor rather than malfunction of the equipment. This results in greater safety, although certainly, a few more shut downs. In regard to the second question, we do not monitor the packing temperature on any of the compressors.

R. F. Bollen
Dow Chemical of Canada, Ltd.

Hydrocarbon contamination of an air separation plant

Here's a practical example of a safe shutdown, decontamination, and derime of an oxygen unit in an ammonia plant.

A HYDROCARBON CONTAMINATION incident, which occurred in the air separation plant at Dow Chemical of Canada Ltd. in Sarnia, Ont., is the subject of this case study. On January 14th, 1959 an underground propane storage well located 600 ft. south of the ammonia plant overflowed allowing a mixture of propane and propylene with small quantities of other hydrocarbons to vent to atmosphere.

The pilot light arrangement on the vent pipe which was supposed to ignite the mixture under such emergency conditions failed to operate and the hydrocarbon vapors from the resulting spill were directed towards the air intake of the air separation plant by a south wind. This air pollution necessitated the shutdown of the air separation plant for nearly 5½ days in order to safely purge the oxygen and hydrocarbons from the cold box and to carry out a normal derime and start-up.

The first indication the ammonia plant operators had of the spill was the strong odor of hydrocarbons in the atmosphere. Adjacent hydrocarbon plants and plant security guards were immediately requested to try to determine the source of the hydrocarbon spill. As the odor of hydrocarbons became stronger the Johnson Williams gas detectors located on the ceiling above the compressors in the ammonia plant triggered. These detectors are calibrated to sound an alarm when the combustible gas concentration surrounding the detector exceeds 20% of the lower explosive limit. Gas tests with an M.S.A. gas tester in the area immediately to the south of the ammonia plant also gave results of 20 to 30% of the lower explosive limit.

Ammonia plant supervision were advised of the situation and instructions were given to purge the liquid oxygen from the air separation plant immediately and to prepare for a plant shutdown. The plant was completely shut down within 35 min. from the time the odor of hydrocarbons was first noticed by the operators. However, purge of the liquid oxygen from the cold box took several hours as the liquid drained from the trays of the columns. In the meantime, plant security guards had located the source of the spill and appropriate steps were taken to stop it.

Most of the hydrocarbons that had concentrated in the liquid pools in the air separation plant were probably removed when the liquid was drained from the cold box. However, it was felt that there was still sufficient liquid oxygen and possibly liquid or solid hydrocarbons still on the trays of the columns or trapped in low points in the cold box to represent an explosion hazard of considerable magnitude. Several precautionary measures were taken to minimize the possibility of an explosion and to protect personnel. Such measures included:

(a) No work or footwear which would produce static sparking was allowed in the area.
(b) Care was taken in the operation of ferrous purge valves which might have induced internal sparks.
(c) A minimum of personnel was allowed in the area of the cold box following the shutdown and throughout the entire purging operation that followed.

The importance of these precautions was emphasized by an occurrence during the analysis of a sample of liquid oxygen that had been withdrawn from the vaporizer of the air separation plant shortly after the shutdown. An attempt was being made to determine the hydrocarbon content of the sample. During the analytical procedure a small explosion occurred in the glass absorption train of the apparatus as the hydrocarbons that had been in the oxygen were being desorbed from silica gel prior to passing through the combustion furnace which converts the hydrocarbons to carbon dioxide.

The concentration of hydrocarbons in the air used to desorb them from the silica gel apparently exceeded the lower explosive limit and when the mixture reached the furnace it flashed back to the absorption train and exploded. To achieve this concentration

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in the desorbing air the concentration of hydrocarbons in the original liquid oxygen sample must have been extremely high.

Proposed safety plans

The problems and hazards of removing the oxygen and hydrocarbons from the air separation plant were thoroughly discussed before any corrective measures other than draining the liquid oxygen from the cold box were taken. Initially, consideration was given to the purge procedure suggested by other air plants that had undergone hydrocarbon contamination to some degree. Most of these procedures suggested that the equipment located ahead of the air separation plant, *i.e.* the caustic scrubber, air chiller, air drier, and knock-out pots, be purged free of hydrocarbons with air from the air compressor.

When all hydrocarbons had been removed from the system the air could be admitted to the air separation plant via the normal air inlet and used to systematically flush the exchangers, columns, and filters of the air separation plant until there were no traces of hydrocarbons in the effluent air. The cold box could then be started up and when oxygen and oxygen-rich liquids were obtained in the columns, this too would be purged until analyses indicated that there were no hydrocarbons present in the liquids. The air separation plant could then be brought back into production. However, recognizing the fact that an explosion hazard still existed, at least during the initial stages of purging the air separation plant with air in this manner, further information and recommendations as to the handling of the problem were sought from the Dow Chemical Co., Midland and L'Air Liquide Society in Montreal.

After several consultations with representatives of both companies a procedure was developed for the safe purge and derime of the air separation plant. This procedure had three main phases:

(a) **To dilute the oxygen concentration** in the air separation plant to a low order with nitrogen while maintaining temperatures low enough to keep the vapor pressure of the hydrocarbons present in the cold box as low as possible, *i.e.* to keep the concentration of hydrocarbons below the lower explosive limit.

(b) **To slowly raise the temperatures** in the air separation plant with warm nitrogen to gradually vaporize the remaining oxygen and solid or liquid hydrocarbons in the columns and purge them from the cold box.

(c) **To carry out a complete and thorough derime** of the air separation plant.

Safe decontamination

Under the initial phases of the procedure the oxygen and hydrocarbons were to be purged with N_2 introduced through the nitrogen pass of the air separation plant. It was reasoned that since all of the hydrocarbons that had entered the cold box should have been trapped out in the air feed side of the exchangers or in the columns or hydrocarbon filter, it would be extremely unlikely that there would be any hydrocarbons present in the nitrogen pass out of the cold box. By introducing N_2 back through the nitrogen pass it would be cooled down to temperatures close to those existing in the columns before it came in contact with any hydrocarbons, thereby reducing the risk of thermal shocks which might conceivably cause an explosion.

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During this phase of the purge procedure the velocity of the effluents from the various purges were to be kept very low and the temperatures in the air separation plant were to be raised very slowly so that the concentration of hydrocarbons in the effluent purge gases could be kept below the lower explosive limit at all times. The temperatures in the air separation plant were to be gradually raised in this manner until they were all above −100°F at which time it was considered that a complete and thorough derime could be started.

Approximately 150,000 std. cu. ft. of N_2 was used to purge the air separation plant. To conserve N_2 as much as possible the once-through method of purging was discontinued as soon as the first phase of the purge procedure had been completed, *i.e.* to dilute the oxygen concentration to a low order. At this point the concentration of oxygen in the air separation plant had been reduced to less than 2%.

For the second phase of the purge procedure, namely to raise the temperatures with warm nitrogen, the N_2 was passed through a steam heated exchanger and then introduced to the cold box via the normal air inlet where it passed through the shell side of the exchangers to the columns of the cold box. The effluent N_2 was taken from the tube side of the exchangers and recycled through the steam heater and back into the air inlet. Sufficient purges were maintained to ensure that the warm nitrogen reached all sections of the cold box. Continuous make-up nitrogen was added to the recycled nitrogen to make up for losses.

Analyses carried out on the effluent purge gas indicated that the oxygen content was reduced to the order of 2% over a period of 24 hours. The hydrocarbon content during this phase of the purge procedure was kept to less than 0.1%. Temperatures in the cold box were gradually raised to −100°F. Analyses carried out on samples drawn from medium pressure column and vaporizer and from the hydrocarbon filter showed no increase in hydrocarbon concentration as the temperatures were raised.

From vapor pressure curves it was established that at a temperature of −100°F the vapor pressure of liquid propane, if present in the air separation plant, would have been 2.94 lb./sq. in. which would have been sufficient to show a detectable concentration of hydrocarbons in the effluent purge gas, (approximately 15% from the vaporizer). Since the analytical results showed no trace of hydrocarbons it was contended that all hydrocarbons had been purged from the air separation plant. At this point the derime of the air separation plant using recycled nitrogen was discontinued and a normal air derime was started.

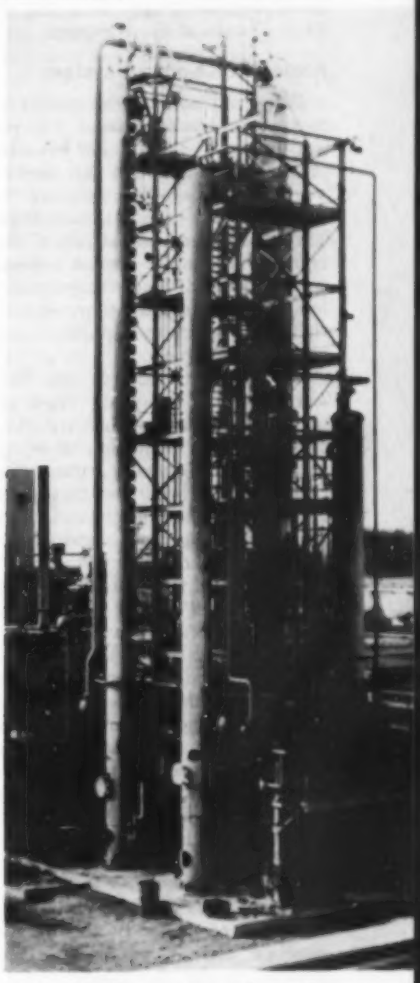
Following the completion of the derime the air separation plant was started up and brought on stream with no further trouble. #

This report on Air & Ammonia Plant Safety will be concluded in June CEP.

J. M. MADIGAN
B. F. Goodrich Chemical Co.

Computer controlled processing

CPI breakthrough! Here are the first *complete* details on Goodrich Chemical's putting a computer to work running a vinyl chloride plant, as revealed to A.I.Ch.E.'s Chicago Section.



Vinyl chloride monomer from the cracking of ethylene dichloride is produced in this plant under closed-loop computer control.

COMPUTER CONTROL of a chemical process became a reality in Calvert City, Ky., this year when B. F. Goodrich Chemical Co. turned over the reins of a vinyl chloride plant to a Thompson-Ramo-Wooldridge RW300 computer.

The digital system is actually designed for control of both the processing of the vinyl chloride and acrylonitrile, two of the company's important basic chemicals. Initial delivery was made in December and the computer took over control of the process unit on January 13, 1960. While details are given here, naturally, it is a bit early to have all the answers on evaluation.

Possibly a brief description of what is meant by a "digital, internally programmed, general purpose type computer" is in order. The digital part implies working with all information in the form of digital numbers, as opposed to working directly with the analog signals normally encountered in instruments. All plant analog signals must be converted into digital numbers. These digits are stored in some type of memory device, usually either a magnetic drum or magnetic cores. The RW300 has a magnetic drum memory rotating at 3600 rpm. The drum is divided into an addressing system, so that the computer can locate any individual piece of data. The RW300 has "tracks" which encircle the drum and are analogous to a street, and "sectors" in each track, which are equivalent to a number address on a street. Each sector contains one computer word consisting of 17 binary bits of magnitude, plus a sign bit. The maximum number that 17 bits can represent is 131,072.

"Internally programmed" means that the same memory device can retain numbers which the computer interprets automatically as "instructions or commands." There are both arithmetic commands (add, subtract, multiply, etc.) and logic commands (transfer on 0 or negative, etc.). The arithmetic commands do the computation in the sequence in which they have been programmed. The logic commands permit the computer to make decisions as to which path of computation to follow. A program consists of a series of these commands, each worked one at a time. It must be perfect in the sense that all options must be anticipated, and every command must be in the exact sequence required to accomplish a given calculation.

A "general purpose" computer usually implies that the programs can be easily changed. The RW300 is general purpose in this sense, but it is also special purpose in that the design of its input-output equipment, the command structure, and accuracy are especially suitable for process control.

Figure 1 is a diagrammatic sketch of the BFG RW300 control system. All parts are complete and operable

except the connections to the acrylonitrile process. These will be completed as soon as we finish our evaluation of the transducers used to convert instrument pressures to and from the electrical signals of the computer.

Analog input-output system

Figure 2 illustrates the system used to receive readings from the plant instruments. A total of 128 have been provided for, although this could be increased. Sixty-four of these are "low-level" signals, typically thermocouples. These are referenced at one of three temperatures in a special reference junction oven. Two of these inputs are fed an independent 10-mv electrical signal to check the amplifiers used to boost these signals.

The other 64 signals are "high-level," or 0-10 v. signals. These electrical signals are mainly transduced pressures from pneumatic flow, temperature, or pressure transmitters. Other signals will be brought in, including an on-line chemical analyzer. The analog input system is completely automatic. The 128 signals are read, one at a time, in eight seconds. The low-level signals are amplified, and all signals are converted to digital form and stored in the computer's magnetic drum memory in Track 08. This is all done independently of the operation of the computer's programs. When the computer needs the value of a given process instrument, a program reads this instrument from the appropriate address in Track 08. Thus, no computer time or space is needed to bring the readings into the computer's memory.

Figure 3 shows the output system that we are using. In this case the program stores the desired digital number in the designated sector or address of Track 07. The computer hardware continuously picks up the number, converts it to analog form, and maintains this output voltage through its own feedback system. The pressures developed in the electrical-to-pressure transducers are sent to the cascade position of a pneumatic controller where it fixes the set-point of that particular instrument.

We had many chances to test this system thoroughly during the ringing out of all the input-output equipment. We have always found this system to be sound and within our tolerance of 0.1% accuracy.

Computer operation

Actually, much of the analog input-output system is an integral part of the computer. But for discussion, we can refer to computer operation in the

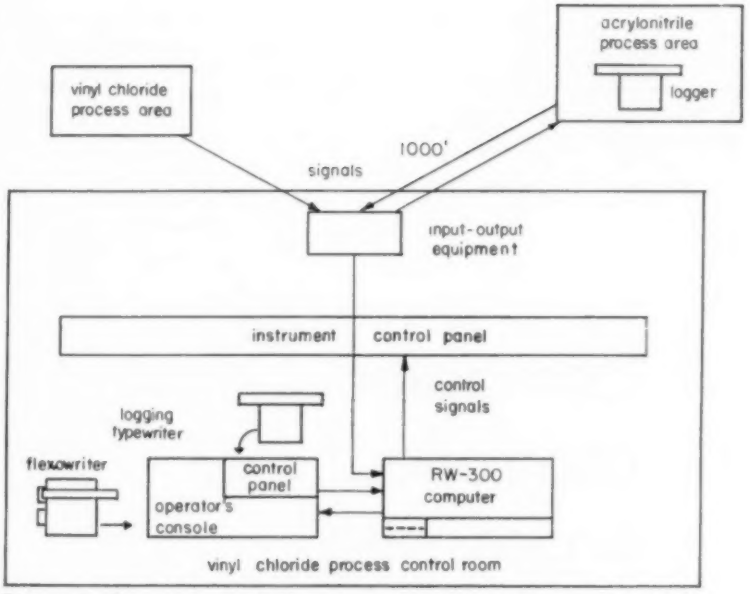


Figure 1. Computer control system as applied to B. F. Goodrich's Calvert City vinyl chloride and acrylonitrile processing plant.

context of an internally-stored program which executes one operation at a time in traditional digital computer fashion. Figure 1 shows the relationship of the various digital input-output devices used by the operators, engineers, and the computer for communication. The two loggers are limited to typing numbers (or symbols) in the upper case position of these keys. The Flexowriter is fully alphanumeric, and, under program control, it can type appropriate messages.

The RW300 memory consists of 64 tracks of 128 words or 8192 locations. Any location can hold data or a command. One track contains a permanent program used exclusively for loading prepunched paper tapes. Another track is used for fast-access storage to speed up certain types of computations. Track 08 in this computer receives the digitized analog input signals. Of the remaining 61 tracks, only 8 tracks can be written in the normal course of computation, and two of these are guarded so that they cannot be written in accidentally. All of this is done to insure maximum protection for our programs, the output signals, and the process flow accumulations.

The heart of the programming system is a master program called the "executive routine." It is essentially a timing diagram for all of the duty cycles that the RW300 performs.

Let us assume that the computer is in normal operation and follow through the logic of the executive routine. The first step is to run a check or test problem. This exercises the computer circuits to their fullest and includes sending out and receiving a test signal that checks the complete analog-to-digital and digital-to-analog system. If it fails this check, the program puts the computer in a STOP mode and indicates a computer failure.

If it passes this test, the program then reads a digital clock. Once it knows the time, it starts down its list of duties, arranged in their order of priority, to see if it has a duty to perform. The present timing and priority diagram is shown in Table 1.

The acrylonitrile control equations

Table 1. Timing and priority diagram.

Every 5 minutes (starts on the hour)	Scan vinyl chloride process Scan acrylonitrile process
Every 20 minutes (starts at 10 past the hour)	"20-minute" control equations
Every hour (on the hour)	Log vinyl chloride process Log acrylonitrile process
Every 8 hours (initial time 00:05)	Vinyl chloride optimization calculation
Every 24 hours	Vinyl chloride daily log Acrylonitrile daily log

are also expected to occur every 20 minutes.

What does each of the programs above actually do? The *scanning* program reads each instrument from Track 08 and tests for a "hard-over" failure. We consider 2-10 v., which is equivalent to 3 to 15 lb./sq.in., as normal for high-level signals and 1 to 10 mv for thermocouples. If it fails this test, the time and the instrument's identification name are typed in red on the Flexowriter. If the instrument is within range, the raw voltage is converted and stored in this instrument's normal units, °F, lb./hr., cu. ft./hr., or lb./sq.in. Several of the variables are further tested over a narrow range. These "alarm scans" are similarly announced on the Flexowriter with the addition of the numerical value of the variable. Once either type of announcement has been made, it is not repeated until the instrument comes back in range and then similar messages are typed in black.

The *twenty-minute control* and the *optimization* programs calculate the new control set-points, test them to see if they are logical, and store them in Track 07. The *hourly logs* give a complete type-out of all variables, including calculated terms such as the reactor conversion and stream concentrations. All flows are hourly averages of the 5-minute scans, and the pressures and temperatures are instantaneous.

The *daily logs* give a rather complete engineering analysis of the day's operation. These include totalized flows, efficiencies, and the new correlation constants that the adaptive parts of the math model have calculated. Both the hourly and daily logs use the appropriate logger, and the acrylonitrile announcements are made on the logger located in that process area.

Assuming no intervention from the operators or engineers, the computer will continue to perform its duty cycles as needed, with the in-between time spent in checking itself and testing to see if it has a duty to perform.

Special requests

The operator's console and the Flexowriter shown in Figure 1 are the operators' and engineers' way of putting in "special requests" for jobs. None of these interfere with the duty cycles, except, possibly, to delay them slightly. At any time we can request a "demand log," which is a type-out of the instantaneous instrument readings, based on the last scan. A "summary scan" is a complete listing of the instruments that are out or alarmed. A "card read" request will read a prepunched card through the Flexowriter for making certain predetermined changes, such as alarm scanning limits, desired production goals, etc. These special requests are usually made by the vinyl chloride process operator.

At the present time, the engineers can also perform certain operations while the computer is doing its normal jobs. For example, we can inspect any location in the memory by the use of the toggles on the operator's console. We can also make the calculations on any one of four standard mass spectrometer analyses for an off-line mass spectrometer at our Calvert City plant. This program obtains the solution of either 16, 24, or one of two 29 sets of simultaneous equations. The input is a punched paper tape in TWX code, prepared with a digitizing device associated with the mass spectrometer. The answers are typed on the Flexowriter in mole-% of each component, plus the average molecular weight. The 29 component analyses take 3½ minutes and fit fairly well between the 5-minute scans.

A complete input TWX tape (usually 10-15 analyses on the same tape) is put into the tape reader and the appropriate buttons on the console pushed. As the computer finds time, it

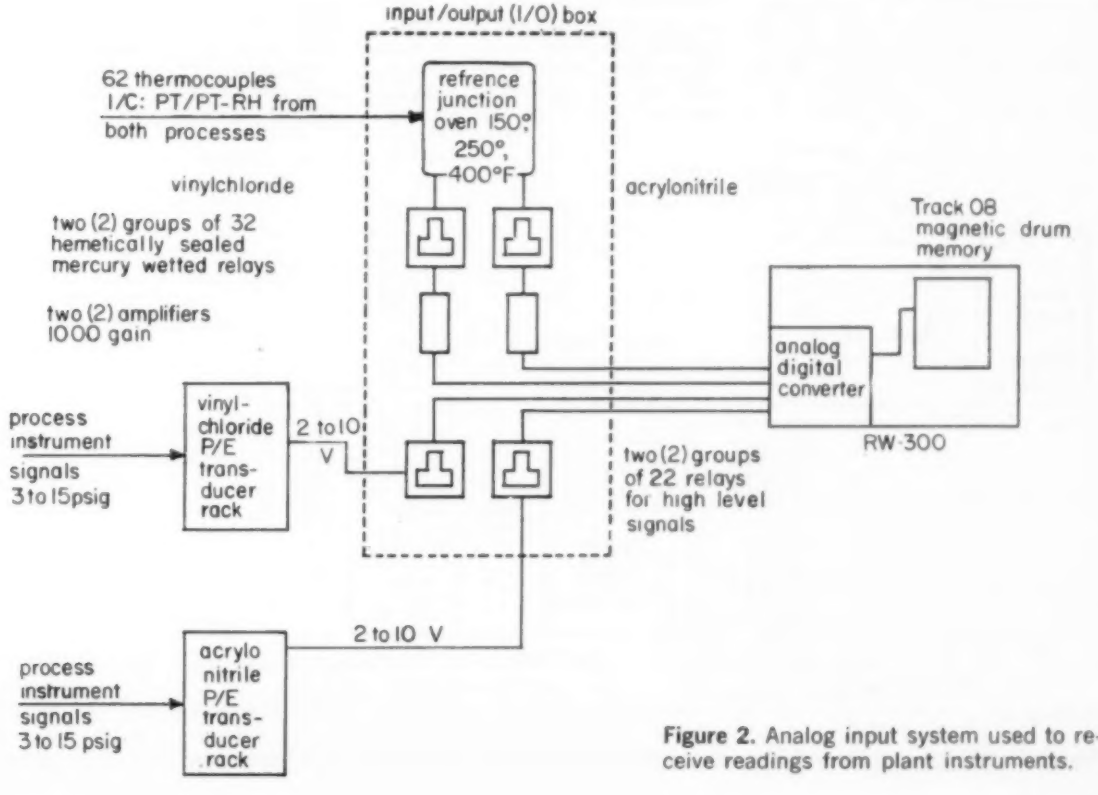


Figure 2. Analog input system used to receive readings from plant instruments.

automatically reads and translates the code, makes the calculations, and types the answers. It does not require any operator attention after the initial loading, although it can be stopped at any time. All duty cycles, of course, have priority, and between each mass spectrometer calculation the computer checks through the executive routine for jobs to be done.

We do not necessarily plan to keep these computations on this computer. Prior to delivery of the RW300, these TWX tapes were sent to our Avon Lake, Ohio, Development Center for computation. But the capability to make all standard analysis calculations will be kept updated, because of the high value of fast results during periods of quality control difficulties.

Control equations

The justification of the system, of course, depends on the design and operation of these programs. After less than six weeks of actual operation, we are not in a position to answer all the questions that may arise and, in any case, every application is unique. Presently, we have capability for 24 controlled outputs. Eight are assigned to vinyl chloride and sixteen to acrylonitrile.

Vinyl Chloride: For process proprietary reasons, we are not in a position to reveal everything the control equations are assigned to do, but the following illustrates the basic method of operation. The vinyl chloride process involves a thermal pyrolysis of ethylene dichloride. Vinyl chloride and hydrogen chloride are produced.

J. M. Madigan has been with B. F. Goodrich Chemical for nearly seven years. Until recently, when his title was changed to development scientist, he was development engineer at the Avon Lake, Ohio, development center. For the past three years, Madigan's work has been primarily in computer applications. He attended Bucknell University, where he received an MS in chemical engineering. Madigan was an instructor in the Chemical Engineering Department at Fenn College for several years.

The eight-hour optimization program is the basic starting point for our control equations. Its objective is to calculate optimum conditions, including feed rate and conversion, for the pyrolysis reactor. In the present program this is done with the restraint of meeting, and not exceeding, a given monthly goal. This goal may be changed many times during the month, and the process, itself, introduces variations due to lost production. These changes and variations are taken care of automatically. At any time the computer can be given a new goal, although this does not necessarily mean that the process can make it. This program utilizes kinetic coefficients for its predictions which are subject to change due to uncontrollable feed stock purity variations. These kinetic coefficients also determine the size of certain corrections that are made to the reactor's instruments. They are automatically updated, based on the last hour of operation. In a sense then, the equations are "adaptive." The kinetic equation is actually expressed in the form of a multiple correlation:

$$C = b_0 + b_1 f_1(T) + b_2 f_2(F) + b_3 f_3(P) \cdots b_n f_n(N)$$

C = Conversion
T = Temperature
P = Pressure
F = Flow Rate
$b_0, b_1, b_2 \cdots b_n$ multiple correlation coefficients

Only b_0 is presently updated on-line.

The other constants will be reevaluated periodically by off-line computation. This is necessary because in a typical eight-hour period, conversion varies so little under computer control that the simultaneous equations cannot be solved accurately.

The twenty-minute control equations work to maintain the optimum reactor conditions calculated by the eight-hour optimization. The computer also calculates the actual conversion from a group of plant physical readings. We are also considering a process stream analyzer for this service. The equations work to adjust the reactor feed rate and heat input to maintain a constant conversion at the optimum value. The ambient conditions and feed impurities are the major uncontrolled variables which work to change the conversion.

In addition, the twenty-minute control program controls the operation of parts of the distillation train. On one

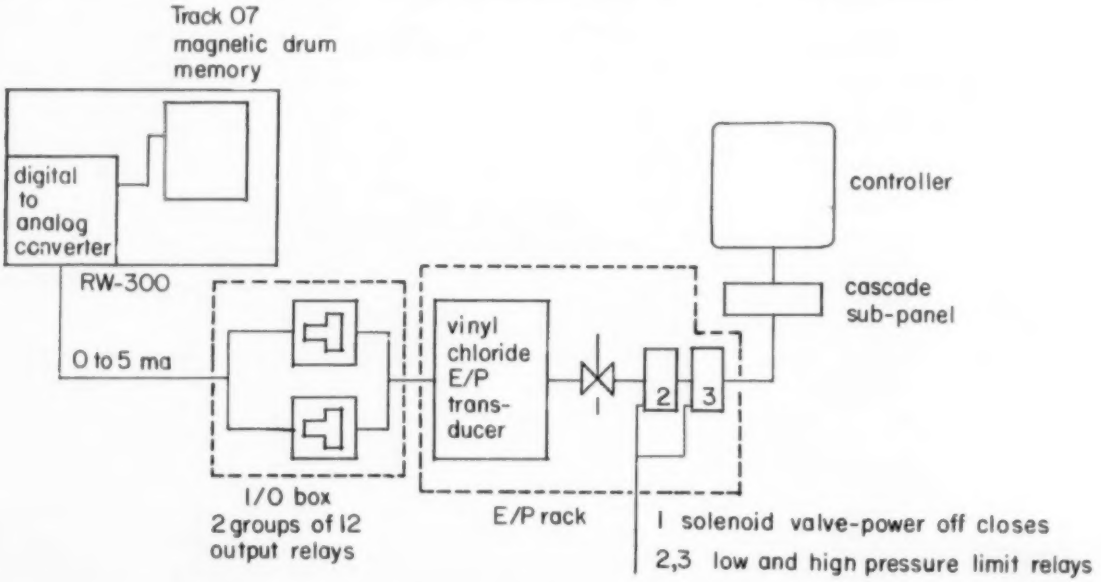


Figure 3. Analog output system converts digital information to analog form for voltage control of process.

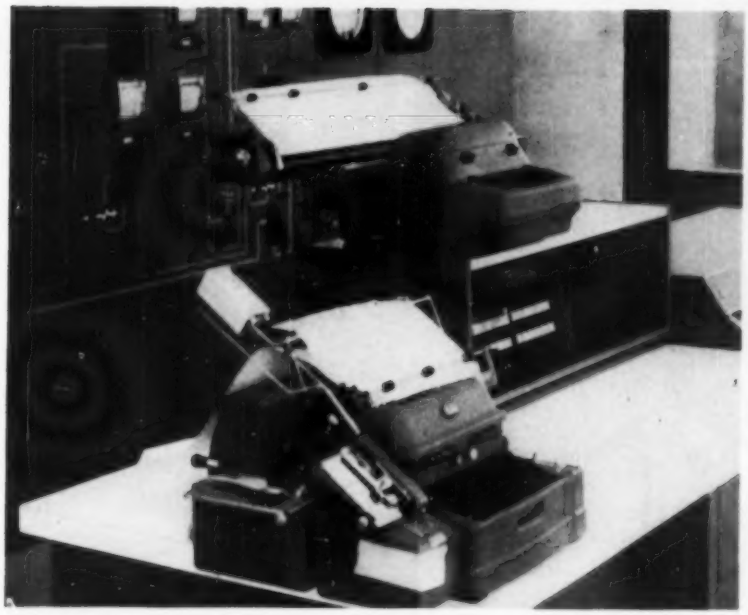


Figure 4. Control room showing control panel, computer (extreme right) and operator's console (foreground).

column this is done through a rather complicated temperature-profile control approach. Essentially, the computer calculates the feed composition from the conversion and flow measurements. From an analysis of various plate temperatures, it determines which way to adjust the temperature control setting at the control point, which is also on a column plate. The result is the maintenance of specification product with minimum losses.

Acrylonitrile: The acrylonitrile process has a different basic problem. It consists of a series of catalytic reactors, each with its own characteristics. The process conditions are adjusted to suit the needs of each individual reactor. Several physical measurements are required, as well as a single chemical analyzer, which is time-shared by all of the reactors.

For both processes, we do not feel that our analysis of what can and should be done for control is complete. The basic flexibility of the digital computer permits the application of completely different approaches, if necessary. The plant technical staff is constantly working to improve the system's utilization beyond our initial goals. The hourly and daily logs will be invaluable in this work.

Fail-safe controls

Our brief experience to date indicates that the process equipment and instruments are bigger problems than the computer system itself. The following is an outline of what we do about both of these problems.

1. First we test the computer. The computer check program works almost continuously and includes a check of the analog-to-digital-to-analog equipment.

2. We test the instrument readings for "hard-over" failure—the critical ones for suspicious data. We also average all flows and certain readings which are important to the control equations.

3. After we make our control calculations, we test the corrections to see if they are reasonable. At the present time, we prefer to inch in on optimum conditions. The computer has full freedom to calculate ideal corrections, but we actually use fractions of the corrections, subject to maximum limitations. In fact, there are myriad rules and regulations which govern the incremental changes to the instruments.

4. Beyond the computer and the transducers we have another protective system. Figure 3 illustrates the system of high-low pneumatic relays which are preset for the range of allowable instrument set-points. This is mainly to protect against output transducer failure, which is equivalent to a control instrument failure.

If we have difficulty or doubt about the data or the computer, we simply do not change the numbers in Track 07; thus, the outputs are frozen at their last set-points.

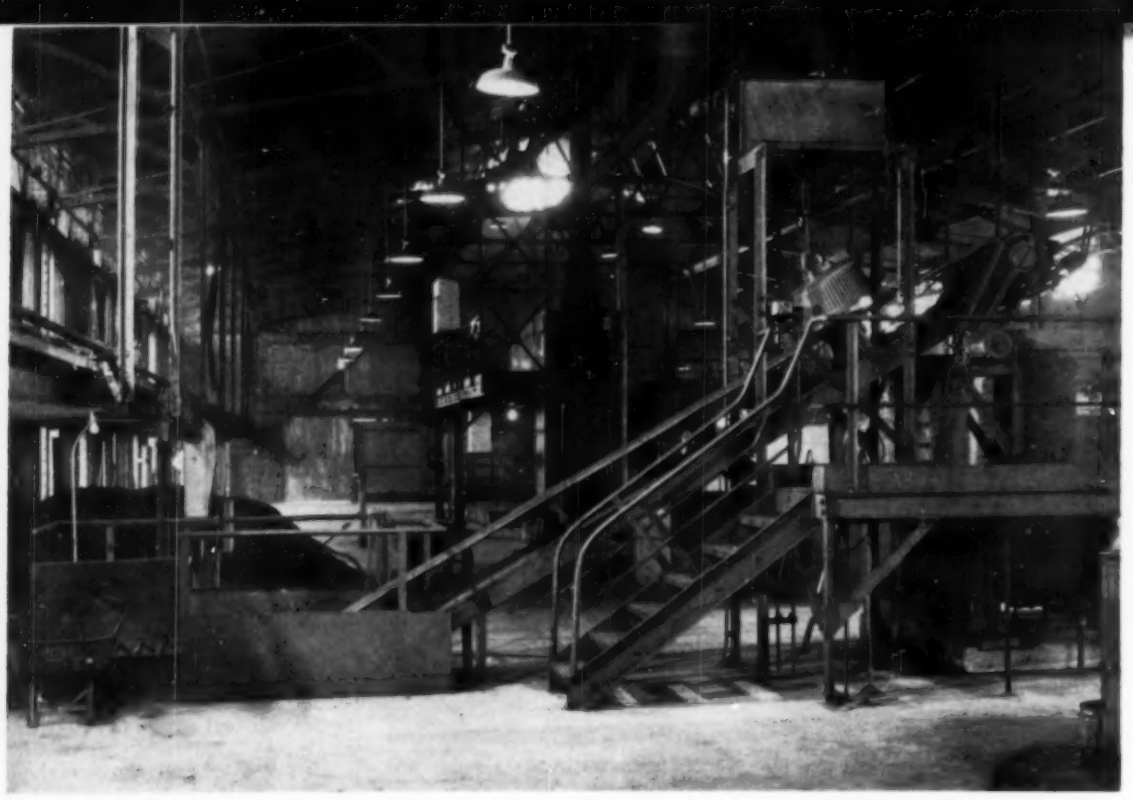
One last word on this subject concerns another possibility; what if the computer gets lost! Basically, the computer itself cannot forget what it is supposed to be doing. But unfortunately, the programs were written by engineers, and there is always the possibility that one program will contain a loop or trial-and-error calculation which the computer cannot complete. We have prepared for this with a "watch dog timer" which the computer, under program control, must reset every six minutes, or the timer will run down and automatically put the computer back into the executive routine. Its services have already been used.

Summing It Up

In summary, we have installed a $225,000 system which is designed to perform scanning, logging, engineering analysis, and control of two chemical processes at our Calvert City plant. The products produced in these processes are basic chemicals for two of the B. F. Goodrich Chemical Company's most important groups of products. Vinyl chloride is used to make Geon polyvinyl chloride resins, and acrylonitrile is used in our Hycar special purpose rubbers. This system is presently operating in the process control loop of the vinyl chloride plant at about 80% of the functions we have designed for it. The computer and its programs have performed beyond expectations. The equipment appears to be at least an order of magnitude more reliable than process instruments and much more reliable than the non-transistorized computers that I have had experience with.

The basic versatility of the digital computer, in terms of flexible and inventive programming, makes it ideal for application of preplanned intelligence to the control of processes. Adaptive control, testing of input data and calculated results, easy modification of the math model, generation of accurate performance data, and the capability for handling multiple units or processes are characteristic of what can be done with a digital computer. This versatility may be essential for computer control, because of the sea of ignorance which surrounds the basic mathematics of most chemical processes.

The limitations that any organization has in successful application of this type of equipment lies with technical inventiveness and imaginations and not with basic capabilities of today's hardware. #



Initial stage of plant where feed is conveyed to Chilean mill. In background, retort stack is behind coked briquet elevator.

L. D. FETTEROLF AND C. M. MCFARLAND
The New Jersey Zinc Company (of Pa.)

Chlorination of titanium ores in a vertical reactor

Versatile process for production of titanium tetrachloride from titanium-bearing ore features agglomerated charge of unique composition, continuous vertical chlorinator, and multi-stage condenser for removing solid iron and aluminum chloride impurities.

IN RECENT YEARS, titanium tetrachloride has increased in commercial importance as an intermediate for the production of both titanium metal and titanium dioxide pigment. Since a large component of the cost of these products is represented by titanium tetrachloride, a low cost process for this intermediate becomes of great economic importance.

The raw materials available for $TiCl_4$ production are rutile, ilmenite, and titania slag. The two former are natural materials and have been available at widely fluctuating costs. Titania slag is a manufactured product containing about 72% TiO_2 and 10% iron as iron oxide. Up to this time the demand for $TiCl_4$ has been met by the chlorination of rutile or other high grade materials obtained by the beneficiation of titanium-bearing ores. However, rutile is believed to be a somewhat limited resource and availability in important tonnages depends on concomitant production of associated ilmenite. It appears, therefore, that a mature industry based on $TiCl_4$ would be encouraged by a process capable of handling a cheaper raw material with avoidance of previous difficulties.

The earliest production method involved passage of chlorine gas through a static bed of ore and coke with periodic addition of charge as the depletion point was reached and periodic removal of residual material. The method was not considered useful for

processing low grade titanium-bearing raw materials. A continuous fluid bed process capable of achieving high recovery was developed, however, the method is limited in applicability as far as ores are concerned. It requires narrow range sizing of both ore and coke and does not entirely obviate problems presented by carry over of dust and solid chlorides which cannot be effectively separated ahead of $TiCl_4$ condensation.

Titania slag appeared to offer the prospect of cheaper $TiCl_4$. The Research Department of New Jersey Zinc Co. accordingly considered various possible processes and developed one based on titania slag. Its feasibility and favorable cost were established by operation of a large scale pilot plant.

Process description

The following objectives were believed requisite for commercial success:

1. A continuous process capable of sustained operation with high percentage chlorination of titania.
2. A process which would tolerate the formation of the residual molten chlorides of Ca and Mg without interference with the chlorination reaction or continuity of operation. This problem is peculiar to titania slag which contains a small percentage of magnesia and a still smaller, but important, percentage of lime.
3. An efficient means of handling the evolved gaseous chlorides through the solid and liquid condensation stages and with a high recovery of solids-free $TiCl_4$.

These objectives were reached by means of the process (*1*) described below and shown in Figure 1.

A vertical column reactor was judged to be the most satisfactory choice as a means of achieving continuous operation. Its simplicity lies in downward movement of agglomerated charge by gravity at a rate controlled by mechanically managed discharge of residue.

A mixture of properly sized titania slag, coals, and binder is first conditioned for development of mix plasticity and then agglomerated by passage through Belgian rolls for briquet formation. The briquets are coked to develop a hard, tough structure and to eliminate volatile matter. The hot, coked briquets are then charged to the vertical reactor and subjected to the action of a countercourrent stream of chlorine gas. The resulting gases exit near the top of the reactor into a solid chlorides condenser, which is operated above the dew point of $TiCl_4$. This condenser removes a major proportion of the contained iron and aluminum chlorides.

The cooled gas from the solid chlorides condenser enters a splash scrubber (*2*), which condenses a portion of the $TiCl_4$ and scrubs out the remaining iron and aluminum chlorides. This unit discharges a concentrated slurry of these solid chlorides in $TiCl_4$ suitable for recovery of the $TiCl_4$ in a sludge dryer. The scrubbed gas from the splash scrubber is further cooled to recover $TiCl_4$ without the difficulties arising from the pres-

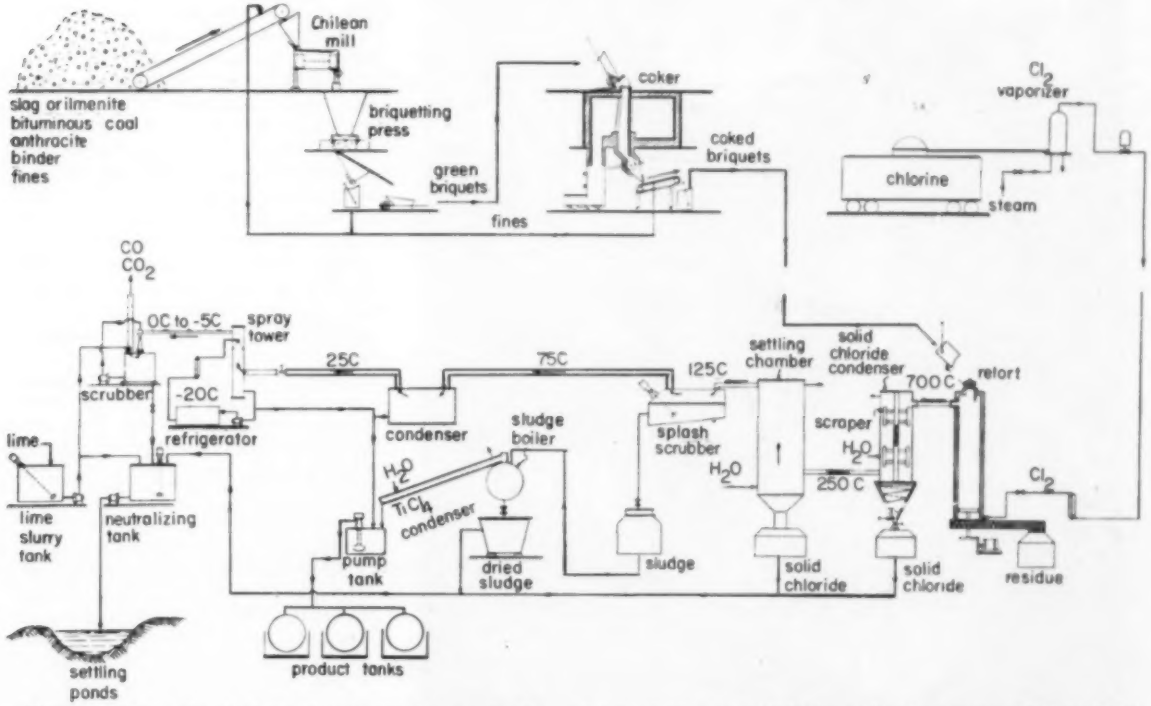


Figure 1. Flow sheet of plant process for production of 5 tons/day of solids-free titanium tetrachloride from titania slag.

ence of iron and aluminum chlorides. This process was developed by operation of a pilot plant having a design capacity of five tons of $TiCl_4$ per day.

Charge preparation

The basic mix adopted for chlorination was roughly 50 parts titania slag, 25 parts bituminous coal, 25 parts anthracite coal, and 5 parts sulfite liquor binder. Fine sizing is required for high chlorination efficiency and for development of adequate strength of the agglomerates fed to the chlorinator. Weighed mixes were conditioned in a Chilean mill and briquetted in a Belgian roll press to form pillow-shaped briquets measuring 1¼" × 1¼" × ¾".

The requirement of strong briquet structure is met by coking of the green briquets. The coking treatment also is essential for elimination of the volatile constituents of the coals, since any appreciable residual content of hydrogen would result in a prohibitive consumption of chlorine in the chlorinator.

The pilot plant coking furnace consisted of a vertical chamber having two opposite side walls formed by slotted, refractory shapes. Green briquets were periodically charged at the top and discharged at the bottom with transverse passage of hot gas. A preferred method of coking involves continuous, autogenous operation by forwarding briquets on a reciprocating, step-grate hearth and supplying a stoichiometric quantity of air to burn the volatile matter evolved by the bituminous coal.

Charge composition and briquet quality are vital factors in assuring good chemical reactivity and continuity of chlorinator operation. The essential constituent of the mix, other than titanium-bearing material, is bituminous coal of the high thermal fluidity type. The strength of the coked structure is enhanced by fineness of both the titanium constituent and the bituminous coal. Roughly equal proportions of titania slag and total coal are needed despite the fact that this represents a large carbon excess over the theoretical required for chlorination. The high coal usage results from the requirement that briquet integrity be maintained throughout the chlorination period. This is assured only if there is ample residual coke structure after consumption of that portion required for chemical reaction. Maintenance of briquet integrity during chlorination results in free descent of the charge through the reactor column, and avoids high back pressure and channeling of gas flow.

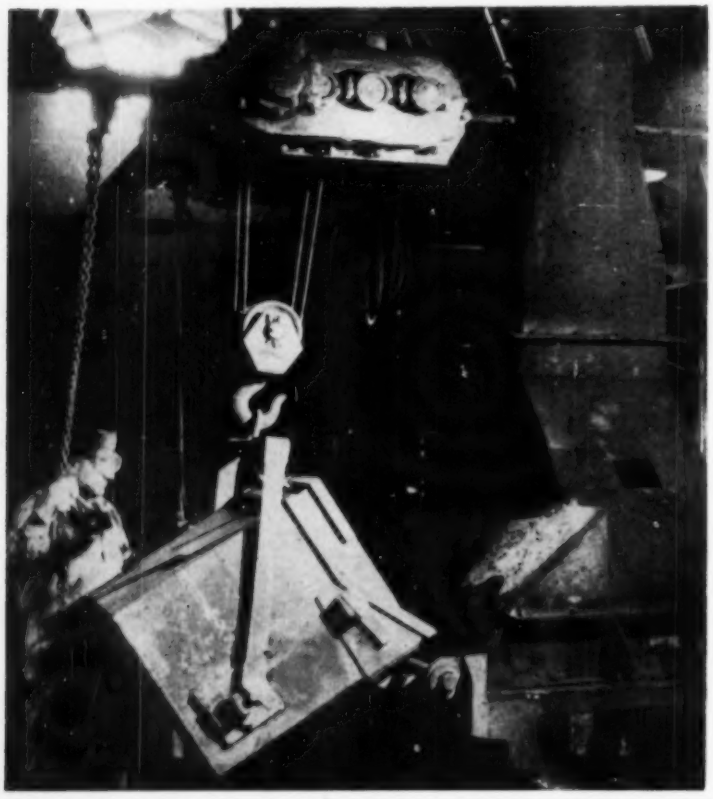
Certain characteristics of briquets relating to internal structure are also important. One of these is high porosity to permit easy inward diffusion of Cl_2 and outward escape of reaction gases. Bituminous coal develops this type of structure upon coking. However, the inward progression of reaction occurs at a decelerating rate, thus imposing a limit on briquet size.

The porous briquet structure also solves the problem of calcium, magnesium, and other chlorides which are molten at chlorinator temperature and residual because of low vapor pressure. These chlorides tend to cause caking of unagglomerated charge with attendant bridging, accretions, and blockages. A briquet undergoing chlorination develops a sponge-like structure with ample absorptive capacity for holding the molten chlorides. Their retention within the briquet effectively excludes them as a source of difficulty in operation.

Chlorination

The design objective was a chlorinator having a capacity of about 5 tons of $TiCl_4$ per day. It was expected that a column of 30 in. I.D. and 15 ft. height would be capable of that output. The reactor column was a steel shell having a 42-in. diam. and lined with refractory to maintain a reasonable shell temperature. A water-cooled, rotary table discharge was provided at the bottom and residue was extracted continuously at a rate correlated with the charge rate. A screw conveyed the residue to a sealed canister. Cold chlorine gas was metered into the bottom of the column. Coked briquets at a temperature of 600-700°C were charged intermittently at a 400-to-700 lb./hr. rate through a top opening maintained under tight seal except for the brief charging periods. Reaction gases left the chlorinator through an opening located a few feet below the charge cap.

The chlorination of titania is accompanied by chlorination of other charge constituents in varying degrees. Prior experimental work had indicated that at least 90% chlorination of titania should be realized at a hot zone temperature of 850-900°C as measured at the inside face of the refractory lining. At this operating condition, the temperature at the center of the charge is about 100° higher. Data on



Bucket of hot coked briquets being charged into the top of the chlorination retort.

average per cent chlorination for a continuous run of several weeks duration are shown in Table 1. Chlorinations as high as 93-94% were sometimes obtained during the pilot plant runs. The average figure above covers a period during which low chlorination efficiency was obtained on occasion as the result of mechanical failures and other difficulties.

A production rate of 7 tons/day was achieved with 90% and higher chlorination of titania. The maximum rate

Table 1. Pilot plant chlorination data of titania slag.

	Chlorination in continuous run	Predicted chlorination†
TiO_2	90.5	90
FeO	97.5	98
MgO	68	65
CaO	82*	100
Al_2O_3	63	60
SiO_2	38.5	35
V	87*	100

* Uncertain because of low content in charge.
† Based on small-scale tests.

for sustained operation was determined not by the reactor itself, but by limitations in the facilities for handling the reaction products. No difficulties in controlling reactor temperatures were encountered. The highly exothermic reaction appeared to be somewhat selfgoverning, probably because of the influence of the endothermic carbon-carbon dioxide reaction at temperatures approaching 1000°C.

Solid condensation

The output of the chlorinator was a gaseous product having the following approximate composition:

	Weight percent	Boiling point, °C
$TiCl_4$	51.8	136
$FeCl_2$	5.7	956
$FeCl_3$	4.8	319
$SiCl_4$	4.4	58
$AlCl_3$	4.7	178
$VOCl_3$	0.37	127
COS	0.80	
$COCl_2$	0.88	
HCl	6.6	
CO	13.0	
CO_2	6.9	

Despite the boiling point relationships, condensation and separation of iron and aluminum chlorides prior to condensation of titanium tetrachloride could not be accomplished in a satisfactory manner by conventional means, necessitating development of a separation method which avoided the difficulties common to known practices.

The gases leaving the chlorinator at 500-600°C were passed through a solid chlorides condenser in which

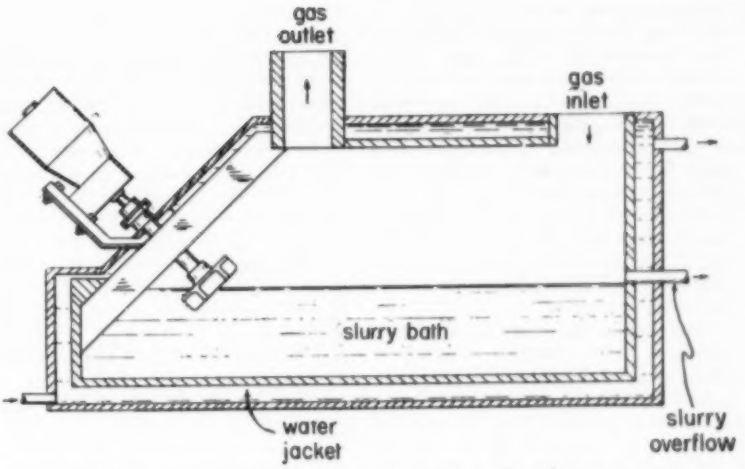
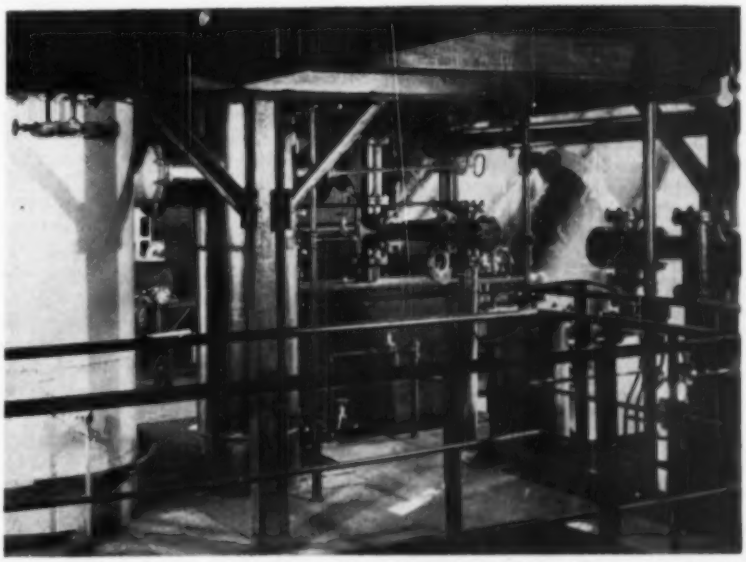


Figure 2. Splash scrubber for final removal of solid impurities from $TiCl_4$ vapor.

the maximum possible condensation and separation of solid chlorides was sought. The first section of this condenser was a water-jacketed tube provided with a continuously operated mechanical scraper which maintained clean walls and high cooling efficiency. The second section was a jacketed chamber of larger cross section to decrease the upward gas velocity and accomplish settling of the solids. This section required periodic scraping of the side walls to maintain the cooling or heating efficiency. The two sections were provided with a common hopper bottom for accumulation of solid chlorides.

The condensing and settling units were so operated that the temperature of the exit gas from the second section was in the range of 120-150°C. This temperature was well above the dew point of titanium tetrachloride, but low enough so that the partial pressures of the solid chlorides, other than $AlCl_3$, were negligible. The theoretical conditions for almost complete condensation of solid chlorides thus existed. However, the collection efficiency was not over 70-75%, partly because of incomplete settling, entrained solid chlorides, and $AlCl_3$ vapor in the exit gas.

Early attempts were made to effect condensation of $TiCl_4$ vapor beyond the solid chlorides condenser by conventional methods, such as cooling of the gas with cold, recirculated $TiCl_4$.



Plant equipment below top floor level shows section of chlorination retort at left, chloride condensers in center, and top of splash scrubber in right background.

Serious problems were encountered in clarifying and cooling the relatively large volume of $TiCl_4$ required for condensation in this manner. The difficulty was caused by the entrained solids clogging the various components of the recirculating system, including pipe lines, recirculator pump, heat exchanger, spray tower, spray nozzles, and control instruments. Eventually a splash scrubber was developed to remove the remaining solids from the cooled gas exiting from the solid chlorides condenser.

The splash scrubber is a water-jacketed steel chamber holding a slurry of solid chlorides in $TiCl_4$ maintained at proper liquid level by a continuous overflow pipe. Its essential features are shown in Figure 2. Gas and entrained solids from the solid chlorides condenser enter into the top at one end. A motor-driven, inclined impeller produces a shower of slurry droplets in such profusion that the cross section of the chamber is effectively curtained by the liquid spray. The gas outlet from the scrubber chamber is through the roof remote from the inlet so that the flow of gas must traverse the interposing curtain of slurry. The solids are effectively scrubbed from the gas and incorporated into the liquid bath with accompanying partial condensation of $TiCl_4$.

In operation, the bath temperature was maintained at the desired level by regulation of the water-cooled jacket temperature. The temperature was so regulated that $TiCl_4$ was condensed only to the extent required to produce a free-flowing slurry not exceeding about 30% solids content. The permanent gases and uncondensed tetrachloride vapors left the scrubber essentially unaccompanied by solids. The splash scrubber thus served as a partial condenser for about 40% of the $TiCl_4$ vapors and as a final scavenger for about 25% of the total solid chlorides to produce a continuously overflowing slurry from which $TiCl_4$ was recovered by use of a sludge dryer.

Liquid and gas condenser

The scrubbed gas, containing CO, CO_2, HCl, most of the $SiCl_4$, and roughly 60% of the $TiCl_4$, left the splash scrubber at 65-80°C. The tetrachloride content was then amenable to recovery by any conventional condensing method by reason of the absence of solid chlorides. The efficient and trouble-free performance of the splash scrubber suggested use of a similar unit for recovery of that part of the tetrachloride condensible at about 20°C. Such a unit was operated with industrial water cooling to condense a clear product.

The condenser operating at 20-25° failed to condense $TiCl_4$ in amount corresponding to 4-5% of the total production and condensed only a relatively small proportion of the $SiCl_4$. The final condensation of tetrachloride from the permanent gases was accomplished by contact with refrigerated $TiCl_4$ in a packed tower. At −20°C, the loss of $TiCl_4$ in the waste gases amounted to only a small fraction of one per cent of the total production.

The waste gases from the final condenser contains CO, CO_2, HCl, a small residue of $SiCl_4$ and $TiCl_4$, and traces of Cl_2 and $COCl_2$. The CO/CO_2 ratio is determined by the reaction temperature in the chlorinator and the HCl content by the H_2 content of the coke charge. Ignoring minor constituents, this gas composition approximated 58% CO, 19% CO_2, and 23% HCl.

McFarland

Fetterolf

L. D. Fetterolf attended the University of Illinois, where he was graduated as a ceramic engineer. After a few years work at New Jersey Zinc on ceramic problems, his activities were transferred to metallurgical development, and fundamental metallurgical research projects. C. M. McFarland has worked on metallurgical development problems, mostly in the field of titanium chemistry. As research investigator for New Jersey Zinc, McFarland has studied $TiCl_4$, its purification by distillation, and the use of magnesium and sodium as reducing agents.

In commercial operation, the HCl would undoubtedly be recovered and the balance of the gas used for its fuel value. In the pilot plant, the waste gas was handled through an eductor operated with lime slurry in continuous recirculation with make-up as required. The eductor provided the suction for moving gases and vapors throughout the entire system back to the chlorinator, at the top of which balanced pressure was maintained. Gas scrubbing and neutralization were accomplished with multiple sprays in a scrubbing tower in advance of the eductor. The sprays were operated on lime slurry from the slurry recirculating system.

Process versatility

It is believed that under normal economic conditions titania slag has a definite advantage over ilmenite for the production of $TiCl_4$, therefore this process was developed based on slag operation. However, a test run of several weeks duration was made by direct substitution of ilmenite concentrate for slag in the slag mix. The ilmenite was essentially all in the 48 to 150-mesh size range and was not ground. Titania chlorinations were as high as 90% in spite of the coarse sizing of the ore which adversely affected the reactivity of the briquets. In previous smaller scale tests, the chlorination obtained on milled ilmenite ore was 94%. Direct comparison with titania slag indicated that the response of ilmenite to chlorination is at least as favorable as that of slag.

The condensing and collecting efficiency of the solid chlorides condenser was surprisingly high in view of of the high iron chloride concentrations in the chlorination gas as compared with that from slag operation. The condenser collect at a five-ton $TiCl_4$ production rate was about 80% of the iron chloride produced as against 70-75% for slag. The performance of the splash scrubber was excellent and solids removal was so complete that a clean system was maintained beyond the scrubber.

The plant was not operated on a rutile ore charge, but rutile had been evaluated in earlier small scale pilot studies. High chlorinations were obtained and low production of solid chlorides contributed to the simplicity of the operation.

A process has been developed for producing $TiCl_4$ from high-gangue raw materials, which avoids difficulties inherent in earlier methods. The main features of the process are an agglomerated charge of unique composition, a vertical chlorinator capable of continuous operation, and a mechanical unit which solves the problem of separating iron and aluminum chlorides from gaseous $TiCl_4$. A pilot plant was operated at chlorination rates equivalent to as high as 7 tons of $TiCl_4$ per day with high chlorination of titania. The process is versatile, being capable of handling ilmenite, titania slag, or rutile raw materials, although it was designed primarily for chlorination of titania slag.

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American Cyanamid Co.

Process Engineering a Petrochemical Plant

These tools help a process engineer to optimize an integrated plant operation—intensive analysis, evolutionary operation, and time-series analysis.

THE HIGHLY INTEGRATED, CONTINUOUS operation of the modern petrochemical plant means the chemical engineer becomes specifically a process engineer. While the variety of skills required of the process engineer in a plant such as American Cyanamid Co.'s Fortier plant near New Orleans is no different than those required in any other type chemical plant, the degree to which these skills are applied does differ.

At the Cyanamid plant the petrochemicals process engineer is concerned with the manufacture of monomers such as acrylonitrile and monomethylstyrene. In these processes, any variation among a whole host of operating conditions can affect the entire plant. An engineer working with a batch operation has to be cognizant only of the effect brought about through variation in a single batch. Likewise, instituting variations in a batch process can be done with a relatively large amount of freedom. In a batch operation, the chemical reaction can be carried to a prescribed end point and then stopped after evaluation. These aspects cannot be undertaken with the continued, integrated operation.

Aerial view of American Cyanamid's Fortier petrochemicals plant near New Orleans.

Three techniques which are used by process engineers at Fortier will highlight the kind of tools deemed necessary for process engineering work done in the plant. The first example will show how a well-established technique, intensive analysis of accumulated plant records, was used to obtain an equation which described plant operation. The equation was used to stabilize plant operation during the early phases. The second example will show how evolutionary operation (*2*), a new statistical technique, was used to achieve sizable process yield improvements. The third technique will show how time-series analysis was used to study process dynamics in order to specify adequate control systems.

Intensive analysis

Before the process engineer can incorporate improvements into the full-scale process, some degree of proc-

ess stability must be achieved. A prediction equation which provided a relationship between operating variables and production rate was found useful in achieving day-to-day operating stability in the acrylonitrile process. This equation was worked out by intensive study of plant operating records and correlation techniques. The procedure used in developing the equation is described below.

In the liquid phase catalytic reaction for the manufacture of acrylonitrile, several variables were known to be of importance in controlling the production rate. This reaction is one where acetylene and hydrogen cyanide are continually passed into a solution of cuprous chloride producing acrylonitrile and a host of by-products. It was not known exactly how the effect of each variable was interrelated with the other variables. It became the responsibility of the process engineer to establish a single equation which would serve to predict acrylonitrile production rates as a function of several variables.

The basic assumption, and the starting point for the development of a prediction equation, was that the production rate was a function of the available active copper.

Figure 1 shows a plot of the daily production rates at varying temperatures as related to moles of active copper. It is evident that a relationship existed, but it also was apparent from scattering of the data that one or more of the other variables also influenced production rate. Closer scrutiny of the plotted values indicated the presence of bands of data at various temperatures.

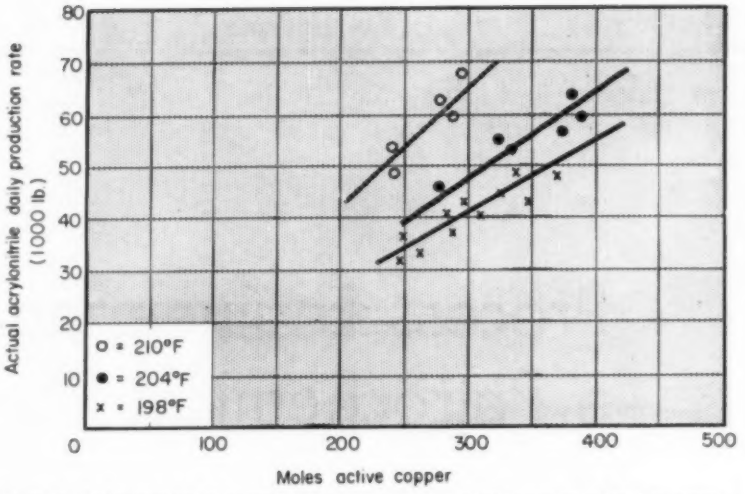

Figure 1. Daily acrylonitrile production rate compared with moles of active copper.

To decrease the scattering of data, rate constants were determined to allow for the inclusion of temperature effects.

It was also known that the partial pressure of a C_2H_2 above the catalyst had a direct influence on the production rate, and from laboratory studies it was determined that the partial pressure of the HCN had an indirect influence on the production rate. With scattering due to temperature adjusted, it was possible to develop a preliminary equation for predicting production rates which when plotted, revealed further scattering of data attributable to by-products.

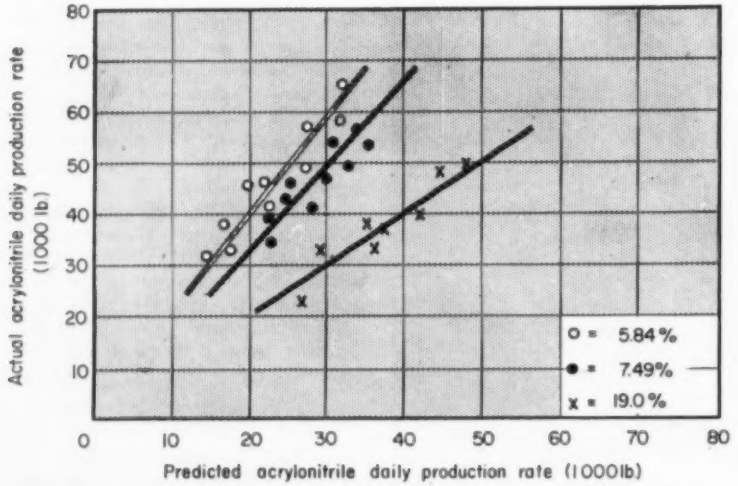

Figure 2. Comparison of actual versus predicted acrylonitrile production rate.

Figure 2 shows the relationship between actual versus predicted acrylonitrile production rates when temperature is compensated for and scattering is found to be caused by varying concentrations of by-products.

Prediction equation

It was now clear that some model had to be written which described production rate as a function of by-product, partial pressures of HCN and C_2H_2, available Cu, and temperature. The explicit model proposed is as follows:

$$R_P = [K_1 - K_2B]\left[\frac{(P_h)_s^{K_3}}{(P_h)_a^{K_3}}\right] \times \left[\frac{(P_c)_a}{(P_c)_s}\right][AC]10^{\left(\frac{K_4}{T} + K_5\right)}$$

where:

R_p = predicted production rate
B = % by-product
P_h = partial pressure of HCN
P_c = partial pressure of C_2H_2
AC = moles of active copper
T = temperature, °R

and where the constants K are estimated from the data and the subscripts "s" and "a" imply standard and actual conditions, respectively. A first approximation of the constants was obtained by graphical procedures. With new operating data, this equation was used for the plot in Figure 3. The plot proved to be within ± 5% accuracy and related the effects of all variables in predicting production rate.

The most important requirement of the acrylonitrile process is a constant rate of production, and since all variables could now be independently

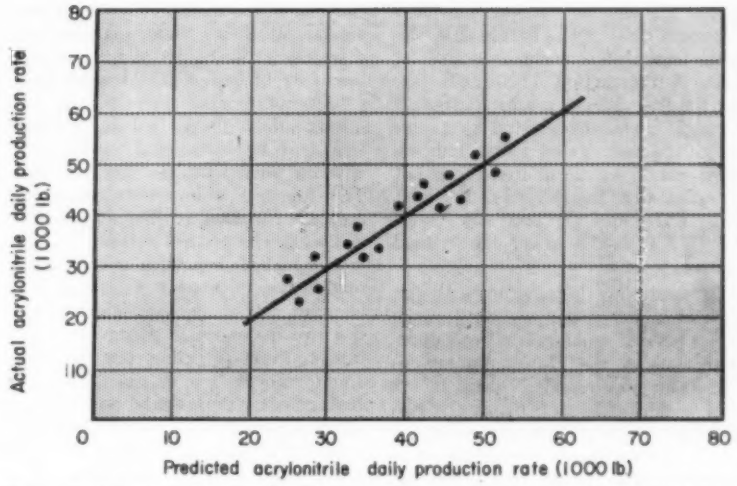

Figure 3. Actual acrylonitrile production rate compared with rate obtained from prediction equation.

controlled at predetermined levels, the prediction equation was found to be extremely useful in establishing stable operating conditions. Also, it was found that a change of any one of the variables could be compensated for within limits by adjustment of other variables as determined in the relationship expressed in the prediction equation for a constant rate of production.

The development and use of the prediction equation represents only the beginning of the continuing effort of the process engineer to optimize the petrochemicals plant. Once a process is producing on a reliable basis other techniques can be used to improve the efficiency of an operation.

After a process can be regarded, in a rudimentary sense, as controlled, it is desirable to take steps toward locating optimum operating conditions. While laboratory or pilot plant data are useful in moving toward optimum conditions, inevitably, scale-up difficulties will require experimentation on the plant equipment.

This particular phase of process improvement has always caused the engineer considerable trouble. The dilemma he faces is that to obtain information on the effect of control variables, obviously he must deliberately vary them. At least two things militate against varying conditions. First, production management now having a stabilized process is not anxious to upset the stability. Secondly, and more important, if the process is profitable at its present level, and if sales are heavy, the motivation to introduce a program which might cause poor yields, poor quality characteristics, etc. is exceedingly weak. In 1957, Dr. George Box of Princeton University suggested a procedure, called evolutionary operation, which at least neutralizes these problems.

Evolutionary operation

The name was chosen because the technique emulates natural evolution in the sense that the elements of variation and selection are artificially introduced into the process. They are introduced in such a way that there is little danger of producing unsatisfactory material, production is not disrupted, and the normal plant personnel can continue to operate the plant on a routine basis.

Slight variation, aside from the normal process variability, is introduced by means of a carefully prescribed pattern. The pattern requires that small changes in two or three control variables are made from the standard operating conditions. Continued manufacture of material under the conditions described by the pattern will allow information to accumulate while material is being produced.

To quote from G.E.P. Box (*1*):

> "The effects of the deliberate changes in the variables will usually be masked by large errors customarily found on the full scale. However, since production will continue anyway, a cycle of variants which does not significantly affect production can be run almost indefinitely, and because of constant repetition, the effect of small changes can be detected."

The second essential component, selection, is made possible by statistical analysis of the data. This analysis will, for example, suggest areas of improved performance, or indicate that one or more variables have little effect on the yield or quality.

As an example of the procedure, we might decide that temperature and concentration of a feed stream are

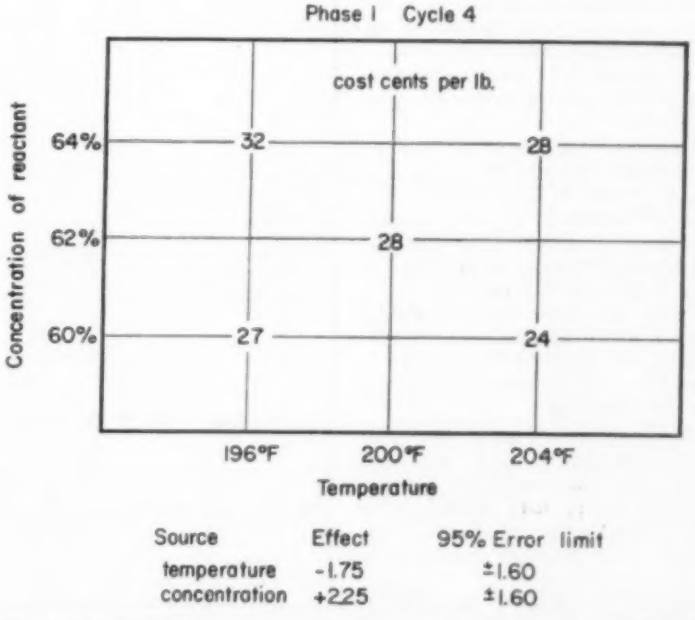

Figure 4. Typical evolutionary operation pattern with partial analysis for increase of temperature and pressure.

likely not to be at their optimum levels relative to cost or product. A pattern would be set up as shown in Figure 4, where the changes in the variables are considered to be small in their effect on the over-all cost of production. The conditions at the point in the center are considered to be present operating conditions.

The identification, phase I, indicates that the pattern is still operating about standard conditions, that is, the position of the pattern has not yet been changed. Cycle 4 means that each cost figure is the average of four separate periods of operation under the indicated conditions.

Changing conditions

A partial analysis appearing under the pattern says that from the accumulated data, a change in temperature from 200° to 204° will decrease cost by 1.75¢/lb., and increasing concentration from 62% to 64% will increase cost by 2.25¢/lb. Obviously, these are subject to error from various sources of variation. The 95% error limits provide a quantitative measure of that variation. The practical interpretation is, that if we increase temperature from 200° to 204°, we can expect to get a decrease in cost somewhere between 0.15¢/lb. and 3.35 ¢/lb. Decreasing feed stream concentration should decrease cost somewhere between 0.65¢/lb. and 3.85 ¢/lb. On the basis of these observations, the recommendation is made that the pattern be shifted an appropriate distance in the direction of increased temperature and decreased concentration. The patterned operation is then resumed in the new location.

One other significant aspect of the evolutionary operation technique was not illustrated in the example. The pattern followed by appropriate analysis has the ability to detect and measure non-linearity in the effect of the variable on the response. If for example, the chosen control variables do not affect the response independently, the degree of the interdependence can be measured through statistical procedures.

Evolutionary operation has been used extensively at the Fortier Plant with significant success. As a matter of fact, evolutionary operation has contributed to the fundamental knowledge of the hydrogen cyanide process.

Hydrogen cyanide is produced by the Andrussov Process which converts NH_3, CH_4, and O_2 over a platinum gauze. All of the reaction data had indicated, and logically so, that the gauze temperature was the controlling factor in the reaction. This is still true, but for the specific reactor design as it exists, it was determined by evolutionary operation that gauze temperature should be considered the result of, rather than the control of the inlet NH_3, CH_4, and O_2 flow rates with the O_2/CH_4 ratio being the critical control.

By operating the reactors with gas concentrations as the primary control, evolutionary operation procedures were used by the Fortier process engineers to improve HCN yield by 4% over a period of approximately two months operation. With the continuation of evolutionary operations, it is expected that further gains will be made.

While evolutionary operation will move a process toward optimum conditions even with a large background variation, ultimately, optimization requires good process controls.

Specifically, once the controlling factors have been determined, to optimize a process it becomes necessary to determine within what range each variable is to be controlled.

Time-series analysis

A technique which was found to be of considerable help in determining the extent of necessary controls is time-series analysis. Time-series analysis, on which mathematical development is still being done, suggests that if we can explicitly characterize measurements of input disturbances to a process and measurements of the resultant effect on the output, a function can be developed which will describe what took place in between. This function, known as a frequency response function, is then a characterization of the control system.

The main fractionator of the monomethylstyrene process (Figure 5) is a complex operating unit. The column has two major input streams in addition to four recycling streams. The fractionator is 9 ft. in diam. and 120 ft. high. It was designed on the basis of 18 theoretical trays and 2 draw-off trays. The main heat source is a hot vapor feed and the secondary is a flash feed. The main vapor feed at design conditions is 24,500 lb./hr. at 1000°F and the flash feed is 51,500 lb./hr. at 330°F. There are approximately 160,000 lb./hr. of material handled. This unit is thus characterized by relatively high flows and short residence times.

Obviously, a column as complicated as this one poses correspondingly complicated instrumentation problems. It was decided to try to characterize the three major control loops by frequency response functions in an effort to achieve better control, thus implying more economic modes of operation.

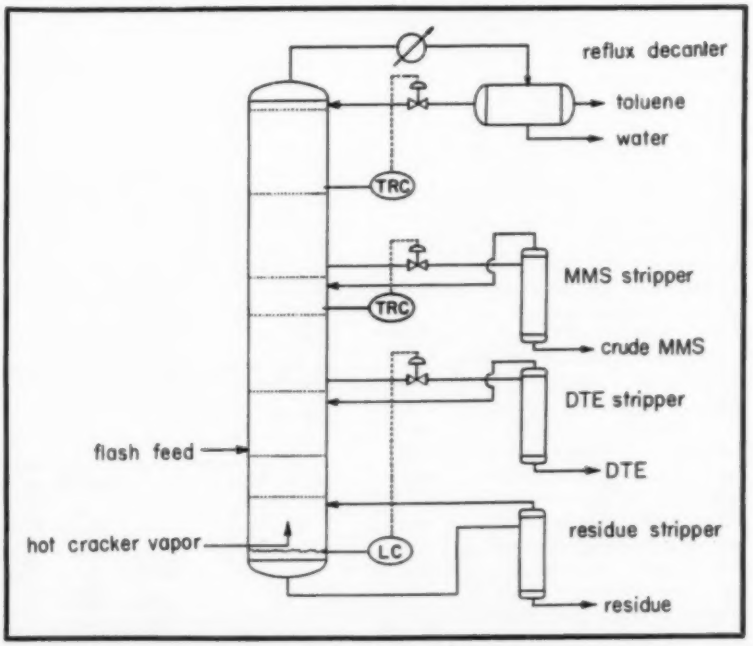

Figure 5. Monomethylstyrene fractionator where better control using frequency response functions was attempted.

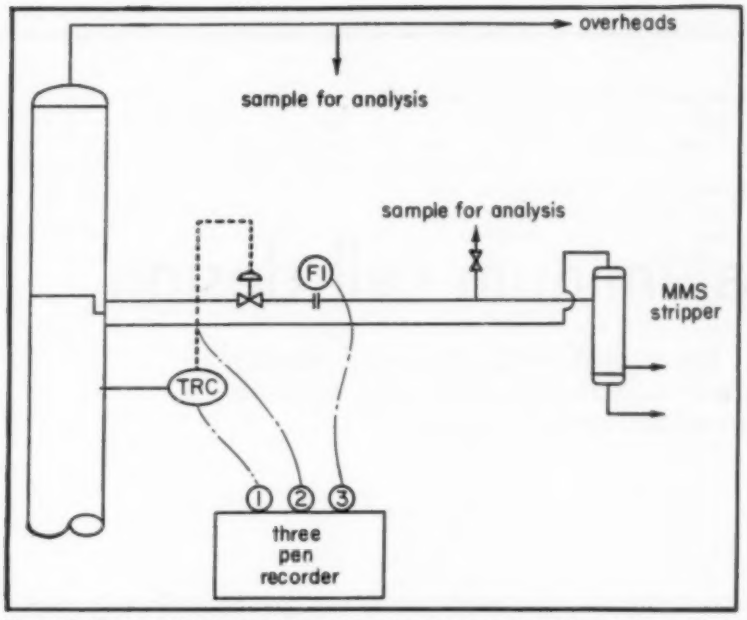

Figure 6. Monomethylstyrene temperature control loop where time series analysis was applied to obtain the frequency response function.

Typically, one of the loops analyzed (Figure 6) was a temperature control system. The control loop here is a classic one. The loop is considered as the portion of the column which converts changes in flow to changes in column temperature with a controller modifying a control valve in a draw-off loop in response to deviations of temperature from a set point. There are, of course, other inputs to the column which modify the temperature at the control point, but these are considered extraneous with respect to the loop under study and are characterized as "noise."

To be somewhat more specific, a frequency response function is the mathematical description of how the process, whose response function is given, modifies in both gain and phase a pure sine wave input. The usefulness of such a characterization is due to the fact that any deterministic input signal may be broken into Fourier components which are sine waves and hence, by the principle of superposition, the output response may be obtained by adding the known effects of all the inputs.

There are several conventional methods for obtaining estimates of the frequency response function. These suffer from the important disadvantage of requiring the imposition of external upsets on the process under study. These upsets may take the form of sine waves, steps, or impulses, all applied pneumatically to control valves. In addition, the study has to be carried out under open loop conditions. As a more practical objection, it is quite difficult to get good results for the phase estimates from sine wave inputs due to the action of the process noise which modulates the output wave form. Steps and impulse inputs run the risk of exceeding the range of linear behavior of the column, whereas large inputs are convenient for accurate chart reading and in overcoming pen friction.

The field of mathematical statistics helps to provide an answer to the problem of finding the frequency response functions of physical systems which overcomes the objections raised. This approach enables us to use as inputs to the process under study the random fluctuations which appear in all chemical systems. Using assumptions which are quite realistic, the mathematical aspect of the problem becomes tractable. We are able then to obtain an estimate of the frequency response function together with a confidence statement concerning the results. This latter point is all important from a practical point of view. Briefly, it enables the control or instrument engineer to assess the design of his system in terms of the actual performance of the system as built. It enables him to try to improve the design of the control system with a prior knowledge of how good his estimate of the frequency response function is upon which his design is based. In addition, the method enables the control engineer to obtain frequency response functions of the controllers which are actually in the process stream.

In this particular instance, the final result was negative in the sense that no further improvement was indicated in this particular control loop, since a narrow range of variation was not necessary to further optimize the process at this point. The existing control instruments were satisfactory. This result, although negative from an improvement standpoint, did serve a valuable purpose for the process engineer. He did eliminate an apparent problem and could now move on to another problem.

Although optimization infers achievement of the optimum conditions, this is never reached. It becomes obvious that the efforts of the process engineer continue, particularly when we consider the fact that many specialists along with process engineers are constantly developing improved techniques.

The process engineering activity in a petrochemicals plant requires the use of many specialists in many areas, and the process engineer must be able to integrate the statistician, the mathematician, and the instrument engineer into a team in which he serves as the coordinating leader. Through the combination and blending of techniques and skills outside his immediate domain, the process engineer works to stabilize, improve, and optimize his process.

Ringelman Cestoni Olson

R. E. Ringelman joined American Cyanamid in 1947, at the Stanford Research Lab. Now at the Fortier, La. petrochemical complex, he took over his present post of chief process engineer four years ago. **D. J. Cestoni** is manager, technical Department, at Cyanamid's New Orleans plant. He also worked for several years at Fine Chemical Manufacturing, in process engineering, and pollution abatement. **L. R. Olson** is a process improvement engineer production analysis section, American Cyanamid New York Office. He studied at Northwestern where he received an MS in chemical engineering.

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ROBERT A. LEWIS
Kaiser Aluminum and Chemical Corporation

Trends in aluminum cell design

Now possible: lower unit costs, increased efficiencies, and higher current capacities due to novel properties of new hard-metal alloys.

THE ALUMINUM INDUSTRY has undergone a rapid growth since the end of World War II. Productive capacity for primary aluminum in the United States has risen from about 600,000 short tons in 1946 to about 2,500,000 short tons in 1959. The production of primary aluminum, furthermore, has become a highly competitive industry in both domestic and foreign markets. This competition, plus rapidly rising capital and operating postwar costs, has provided renewed incentives to improve aluminum cell design and operation.

The literature *1, 2* adequately describes the basic aluminum reduction cell design that originated with Hall and Heroult and its development up to the late 1940's. At the end of World War II, two variations of this basic cell design were in widespread use: the prebaked anode cell, and the self-baking anode, or Soderberg, cell. Both types employed the fused cryolite-calcium fluoride-alumina type electrolyte, which also originated with Hall and Heroult. The corrosive nature of the combination of this fused salt electrolyte and molten aluminum has limited cell lining material to carbon. The need for this carbon lining to contain the molten cell contents, as well as conduct the cathode current from the cell, has been the main factor limiting cell design improvements in the past.

In commercial practice no fundamental changes have been made in cell design, electrolyte, cell operation, or materials of construction since the end of World War II. The trend has been toward increasing cell size and some mechanical improvements in moving parts and auxiliary equipment.

By the end of World War II, commercial cells in the United States ranged between about 20,000 and 50,000-amp. capacity. Development of cells ranging between 60,000 and 100,000-amp. capacity began in the United States immediately thereafter. The incentives to develop larger cells lay in their proportionately lower heat losses, lower manpower requirements per pound of aluminum produced, simplified materials handling problems, and somewhat lower capital costs.

In the immediate postwar period, the Soderberg type cell was the one favored for large-cell development. Reasons for this trend were:

1. No carbon-anode pressing and baking facilities, or separate facilities for connecting electrical conductors to the anodes, are required for Soderberg cells.
2. Large, single-anode Soderbergs require less operator attention.
3. Large, single-anode Soderbergs are more amenable to mechanization than the multiple-anode prebake cells.
4. Because of the restriction of heat losses caused by the large anode, Soderbergs operate at lower current densities than prebake anode cells of the same size, and thus at slightly higher power efficiency.

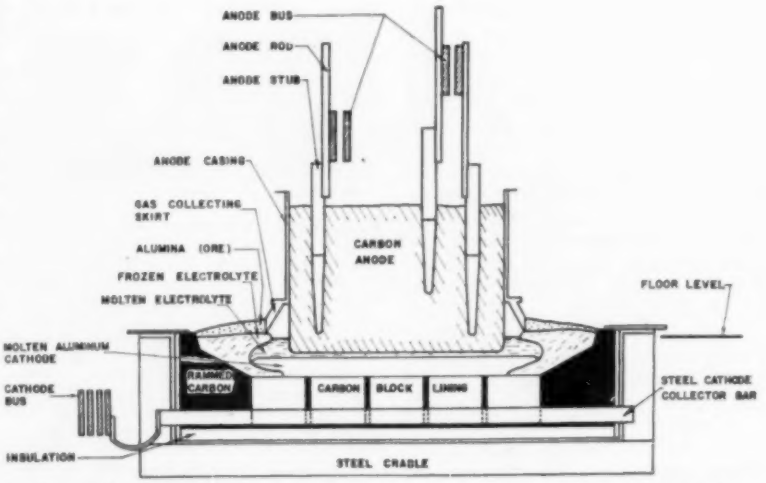

Figure 1. Sectioned schematic of 100,000-amp. vertical stub aluminum reduction cell with Soderberg anode.

Development of large Soderbergs proceeded rapidly in Europe and North America to the point where commercial cells of this type up to 135,000-amp. capacity are in operation today 3, 4. Figure 1 shows a schematic cross-section of a modern Soderberg anode cell, and Figure 2 shows a small group of 100,000-amp. cells of this type at the Kaiser Aluminum and Chemical Corporation Reduction Plant, Tacoma, Washington.

However, the Soderbergs still had a few disadvantages compared to multiple, prebake anode cells:

1. The presence of tar fog in the Soderberg cell fumes complicated the collection and disposal problems in air pollution prevention. This became a dominant factor after World War II, when the size of aluminum reduction plants increased greatly.

2. The lower current density of the Soderberg resulted in less aluminum production per unit of capital cost. Sharply rising capital costs for new reduction plants in the postwar period amplified the importance of this factor.

3. Superior quality could be achieved in the carbon anodes used in the prebake cells because of higher baking temperatures and generally better process control.

4. The Soderbergs required more floor space or working area and thus larger investment in buildings and auxiliary services than the prebakes.

Because of these Soderberg disadvantages, the development of larger prebaked anode cells was also pursued by the aluminum industry, particularly in the United States where capital costs and the air pollution problem are relatively more important factors than abroad. The trend in the development of larger prebake pots since World War II has been toward increasing the anode size and decreasing the number of anodes per cell. This minimizes the amount of handling required and, therefore, lowers costs in the manufacture of these anodes and in the cell operation. As the size of prebakes increased, current densities were lowered to improve power efficiency. For a given size cell, however, current densities of prebakes remain higher than Soderbergs, thus maintaining the prebake cell advantage of greater productivity per unit of size and investment. Examples of the larger improved prebake cells in operation in the United States today are shown in Figures 3 and 4.

The principal mechanical improvements which have been made in aluminum reduction cells since the end of World War II were required by the increasing size of the cells. These improvements were: the mechanization of anode adjustment, mechanization of Soderberg anode stud changing, and the use of mechanical crust breakers 5, in the alumina feeding operation.

Technical problems

The trend toward larger reduction cells has brought with it a number of technical problems, which may eventually limit the size of the cells to about 150,000 amp. unless these problems are solved.

Cell lining life. Nearly all producers have encountered shorter potlining life as the size of aluminum reduction cells has increased beyond 60,000 amp. Mechanical and structural stresses become severe as the size of these

Figure 2. A group of the 100,000-amp. Soderberg cells depicted in Figure 1 in use.

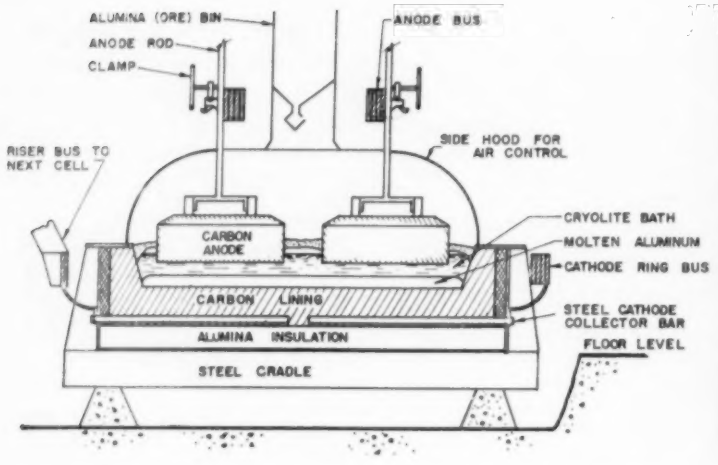

Figure 3. Schematic of modern prebaked anode cell of 85,000-amp. capacity.

Figure 4. A production line of the prebaked anode cells at Kaiser's Ravenswood, W. Va., Works.

cells is increased due to the forces created in the linings by thermal expansion, crystal growth, and alkali attack on the carbon. Furthermore, deterioration of the carbon lining by chemical attack (due to formation of aluminum carbide and slow oxidation of the lining by diffusion of air into the lining structure) is also intensified and aggravates the mechanical and structural problems as the cell size increases.

Because of these effects, the use of rammed, monolithic carbon linings (American practice in the past) has become impractical with cells on the order of 100,000 amp. For cells of this size, it is necessary to use prebaked, block-carbon linings. This type lining is more expensive but can be designed to overcome some of the structural and mechanical problems —not possible with the rammed, monolithic type lining. However, even with the more expensive prebake block type linings, the lining life of cells of 100,000-amp. or more is still shorter than the cheaper rammed linings in cells of 50,000-amp. or less capacity.

Electromagnetic problems. Electromagnetic problems *12, 13* become increasingly severe in aluminum reduction cells as the size increases beyond about 85,000-amp. capacity. Electromagnetic fields resulting from the high currents create large forces on the current-carrying molten aluminum cathode within the reduction cell. Such forces can cause violent agitation in the molten aluminum cathode. In the larger cells these forces can also build up over greater distances than in smaller cells to cause large static differences in liquid cathode surface between various regions of the cell. These phenomena complicate cell operation and the control of anode-cathode separation and voltage. This results in poor current distribution and interference with the efficient operation of the cell.

In large cells, it becomes necessary to resort to shielding or elaborate bus arrangements to offset the effects of these electromagnetic forces. The net result is an increase in the construction cost of these large cells. Here again, an inflexible cell design and lack of materials of construction make it difficult to design around, or otherwise cope with, problems of this nature.

Heat dissipation problems. The third major problem created by increasing cell size is the decreasing amount of surface area for heat dissipation as the volume and size of the cell increase. This means that the current density must be lowered as cell size increases to prevent operating temperatures from becoming excessive and adversely affecting production efficiency and cell life. Here again, the net effect of increasing cell size is to reduce the amount of aluminum produced per unit of floor space, and thereby increase the capital cost per unit of productive capacity.

Because of these technical problems, the industry today faces limitation in cell size in spite of the many advantages inherent in larger cells.

Economic problems

The capital investment required

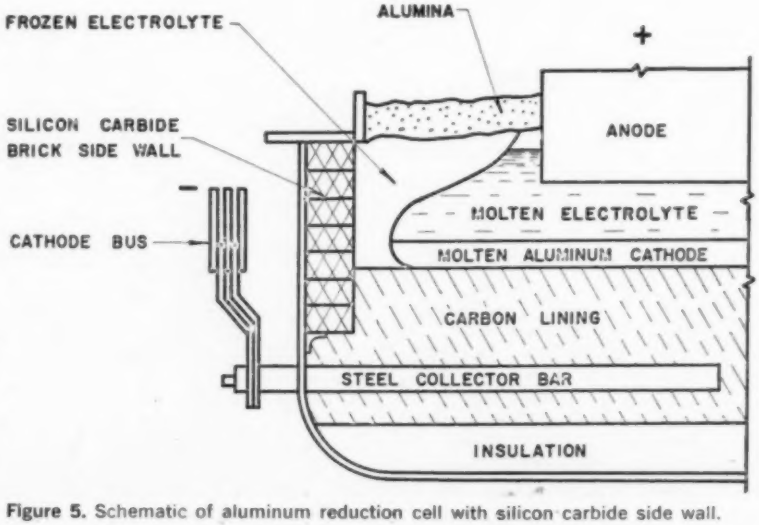

Figure 5. Schematic of aluminum reduction cell with silicon carbide side wall.

per ton of basic capacity is much greater for aluminum than for any other major metal *7*. The Korean expansion required an average investment of about $1000/ton of installed capacity for all American producers, or nearly ten times the cost for facilities to produce steel ingots from raw materials. Continually rising capital costs since then have further emphasized the importance of this factor in the over-all economics of aluminum reduction cell design and operation. This factor now overshadows the benefit of more efficient operation obtained at the expense of cell output by lower current densities. Johnson *6* has recently described these problems and pointed out the desirability of increasing the productive capacity of aluminum reduction cells to decrease capital costs and to bring a faster return on the investment in aluminum reduction plants.

Another factor which has a major effect on aluminum reduction economics is the multiplicity of small production units. The largest cells now in existence produce only about one ton of aluminum per day, whereas the average cell in commercial use in the United States produces about ½ ton/day of aluminum. This means that in applying such improvements as automation, new materials of construction, or modified electrolytes, the cost per cell must be very low for an economical payout for the aluminum producer.

The future

The two most promising avenues for solving the technical and economic problems described, and for improving design and performance of future aluminum reduction cells seem to be:

1. Modification of the fused salt electrolyte to allow higher current density operation and lower operating temperatures.
2. Utilization of new materials of construction to create improved cell designs and to overcome present size limitations.

Either of the above, or a combination, offer much promise for both increasing the productive capacity of aluminum reduction cells and improving ther operating efficiencies.

Electrolyte modification. The volume of recently published literature on properties and potential uses of various fused cryolite systems is indicative of the interest of aluminum producers in the possibilities of improved aluminum cell operation through use of modified electrolytes. The addition of sodium chloride *8* to the electrolyte to lower the freezing point and increase electrical conductivity is attractive because of the low cost and widespread availability of NaCl. Lithium fluoride *9, 10, 11* is more effective than NaCl, but the high cost and limited availability of lithium compounds in the past have discouraged its use in aluminum reduction. The use of a modified electrolyte containing magnesium fluoride, *14, 15, 16* has been developed in Russia to the point where it is reported that two commercial potlines are using this electrolyte today.

Potassium-modified electrolytes, although attractive because of certain properties, have not been practical in the past because of their severe attack on, and disintegration of, the conventional carbon linings *17*. However, new, refractory hard-metal cathode materials bring the possibility of potassium-modified electrolytes back into the picture *18*, since these materials, unlike carbon, resist the attack of potassium.

New materials. Two developments are worthy of note here. One of these is silicon carbide, particularly the silicon nitride-bonded variety of silicon carbide refractory, currently of interest as sidewall lining in reduction cells of otherwise conventional design *19, 20, 21*. The silicon nitride-bonded, silicon carbide refractories are remarkably resistant to attack by molten aluminum, molten cryolite, and the combination of the two. These refractories also have high thermal conductivity and high electrical resistivity compared to carbon. This combina-

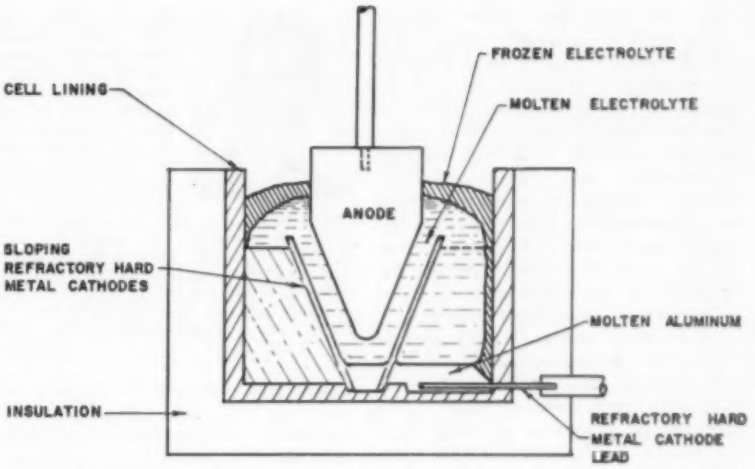

Figure 7. Cross section of aluminum reduction cell using refractory hard-metal sloping cathodes.

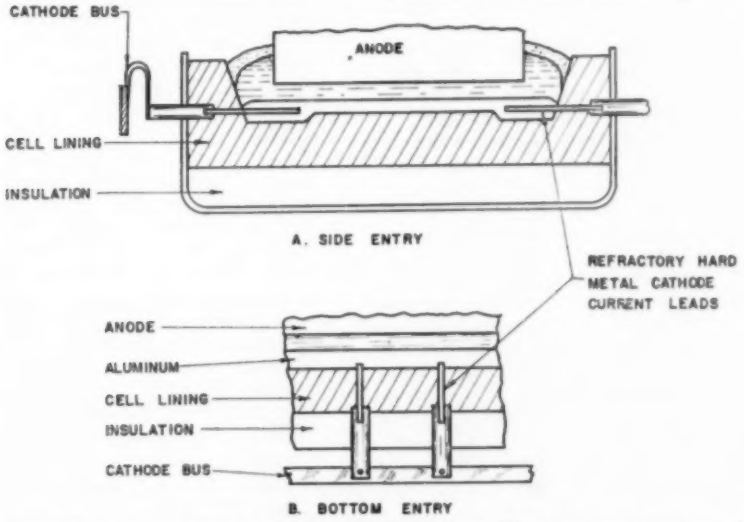

Figure 6. Sectioned view of aluminum reduction cell using refractory hard-metal cathode current leads.

tion of properties offers unique advantages in sidewall construction which permits a great deal more of the available cell area to be used for increased anode area and additional current-carrying capacity. In addition, an inert sidewall with high thermal conductivity may eliminate current leakage through the sidewall as well as unproductive side reactions between carbon sidewalls and the electrolyte and aluminum cathode. An example of the application of these refractories is shown in Figure 5.

The other major development is that of the refractory hard-metal borides and carbides, particularly those of zirconium and titanium which have the unique properties of being inert to molten aluminum and molten cryolite, are wetted by molten aluminum, and have electrical conductivities comparable to that of mild steel at elevated temperatures. The use of these materials in aluminum reduction cell design has been patented by the British Aluminium Company *22, 23, 24* along with several novel cell design arrangements incorporating these types of materials which are shown in Figures 6 and 7.

These refractory hard-metal borides and carbides may potentially serve as cathode leads, or cathode current conductors, to conduct the cathode current directly from the molten aluminum cathode within the cell to the cathodic bus system outside the cell. This potential permits the possibility of all kinds of improved design arrangements of the cathode leads, not possible when steel collector bars (embedded in a thick carbon lining) were required for the dual purpose of containing the molten electrolyte-aluminum combination and conducting the cathode current away. Substantial savings in voltage and space and increases in cell productivity and amperage capacity are theoretically possible by employing these new materials as cathode leads.

These materials open up new avenues in the application of instrumentation and true automation to cells, as well as in the design of the cells themselves.

Development of aluminum reduction cells over the past 80 years has been restricted primarily by the lack of good materials of construction. The recent development and increasing availability of many new high temperature materials of construction have created many possibilities for improving aluminum reduction cell design and performance. However, the economics of aluminum reduction are such that these new refractory materials and electrolyte constituents must not only be available in large quantities, but must also be available at relatively low cost to be attractive to aluminum producers. This presents a real challenge to present and potential manufacturers of these materials, for the aluminum industry represents a very large potential market for such materials if they can be made available in quantity at economical prices.

R. A. Lewis has been with Kaiser Aluminum & Chemical Research Laboratories since 1952. In his post as research supervisor, he is responsible for aluminum reduction research activities. Lewis spent five years with Aluminum Company of America, in research and development. His work took in fused salt electrochemistry; carbon and refractory materials of construction relating to primary aluminum production. Lewis is a member of ACS, ECS, AIME and AAAS.

ACKNOWLEDGMENT

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industrial focus

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Electrolytic production of potassium iodate

Case history study of the design of a small-scale production unit, including design parameters and operating conditions.

ASSIGNMENT—TO FURNISH process design for a plant to produce about 150 lb./day of potassium iodate. Basic design information was obtained from Foerster's *Electrochemie Wosseriger Losungen*. In addition, a few experiments were made in a small laboratory cell to confirm Foerster's results and to evaluate some electrode materials.

Foerster showed that the mechanism of iodate formation was similar to that of chlorate formation, the overall cell reaction being:

$$I^- + 3H_2O \rightarrow IO_3^- + 3H_2.$$

Foerster carried out the electrolysis with platinum electrodes. Reactions went virtually to completion with only minor amounts of residual iodine and hypoiodite, so the current efficiency approached 100%. Reduction of hypoiodate and iodate at the cathode was prevented by addition of chromate, as is done in the chlorate process.

Rate of formation of iodate from hypoiodate increased with increasing temperature, decreased alkali concentration, and increased iodide concentration (see Figure 1). The stepwise nature of the process is indicated by the delay in formation of iodate until the hypoiodate had reached sufficient concentration to react at an appreciable rate. The hypoiodate concentration increased with time until the rate of reaction to form iodate (which is a function of its concentration) equalled the rate of formation.

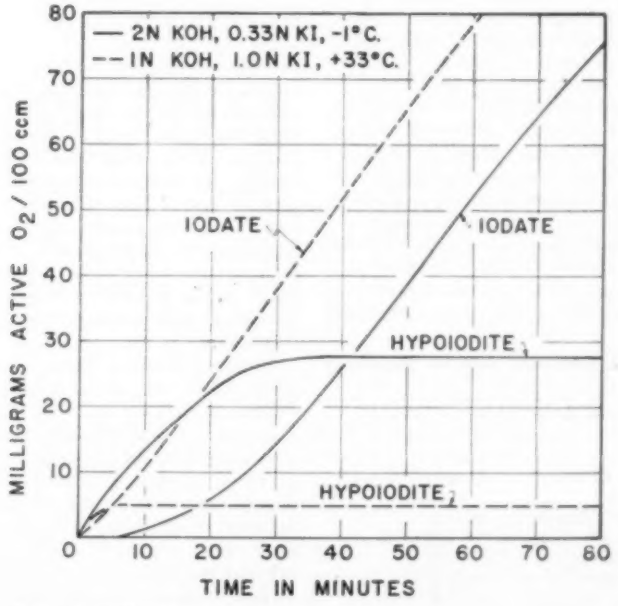


Figure 1. Active O_2 vs. time.

Anode current efficiency

Anode current efficiency can be drastically reduced in two ways. The first is apparently connected with the kinetics of iodide discharge. With a smooth platinum anode, the potential will suddenly increase and oxygen will be evolved, if a certain critical current density is exceeded. The critical current density can be increased by using a low concentration ratio of OH^-/I^-. It is increased by an increase in temperature.

Crystallization of the slightly soluble potassium iodate product at the anode can also reduce current efficiency significantly. This hinders diffusion of the iodide ions to the anode, and the anode becomes polarized. Since the potassium iodate solubility curve against temperature is fairly steep, it is preferable to operate at as high a temperature as possible. However, a compromise must be made because of the limiting current density.

Optimum recommended conditions

According to Foerster, the following conditions are optimum:

15-25 grams KI/100 cc. H_2O
0.2 grams K_2CrO_4/cc. H_2O
0.2 N free KOH

Smooth platinum anode at current

... Length of cycle and volume of the cells were determined from solubility data on the iodide-iodate system.

density not higher than 0.01 amp/cm^2.

Temperature not above ambient.

Graphite anodes

Laboratory experiments established that graphite anodes could be substituted for platimum ones; this was suggested by their use in commercial chlorate cells. Use of graphite anodes offered the advantage of lower cost and, because of the rough surface, prevented polarization at high current densities. Nickel was found to be a satisfactory cathode material.

Design factors

Table 1 lists the number of cells required at various loads to produce 150 lb./day, assuming the cells operate

Table 1. Current and voltage per cell row vs number of cells.

Number of Cells	Amperage per Cell	Volts for Cell Row
1	2130	2.0 – 2.5
2	1065	4 – 5
4	532	8 – 10
6	355	12 – 15
8	266	16 – 20

at 100% current efficiency. Approximate voltage per cell would be 2.0 to 2.5 volts.

Since production capacity was small, the cost of the electrical energy was of less importance in the cost picture than is usual for an electrochemical plant. Thus, in a small-scale operation, with expensive raw material and product, minimizing labor costs and maximizing yield assumed a greater importance. Minimizing investment cost was also of prime importance.

It was decided to use four cells at 500 amperes, and to operate the cells batch-wise. The cells are filled, and electrolysis is then carried out until the potassium iodate concentration reaches the desired level; the solution is then sent to the crystallizers. Fresh feed is charged to the cells and the cycle repeated. Length of cycle and volume of the cells were determined from solubility data on the iodide-iodate system. A 2-day cycle and a cell volume of about 180 gallons were selected.

Current density was selected on the basis of practice in chlorate manufacture, that is, about 20 amperes per square foot. Foerster recommended about 9 amperes per square foot, but this was for smooth platinum which was subject to the polarization effect.

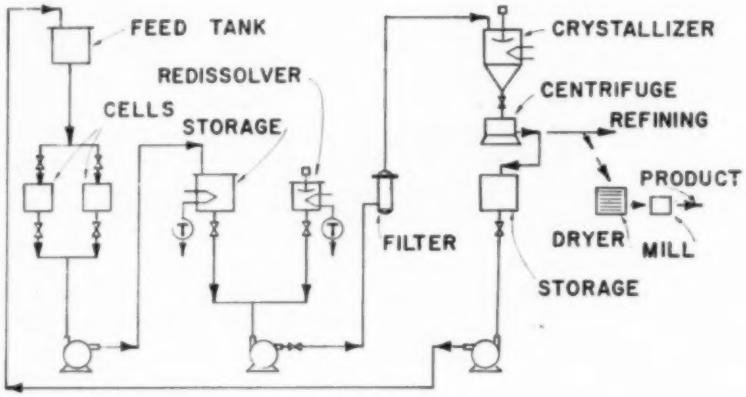


Figure 2. Potassium iodate process flow diagram.

Anode-cathode spacing for this system should not affect current efficiency, since the mechanism of the reactions is generally similar to those for chlorate formation. Therefore, the minimum practical spacing consistent with hydrogen gas removal was employed.

Effect of temperature

Foerster recommended that the iodate cell be operated at room temperature, although he indicated that the chemical reactions were faster at higher temperatures. He states that the smooth platinum anode tends to polarize more readily at higher temperatures. It was assumed that this should not present a problem with graphite anodes. It was, therefore, decided to operate the iodide cells at 50°C which, compared to ambient temperature, lowers the voltage, increases the reaction rate, and increases the solubility of potassium iodate.

A heat balance was made to determine whether cooling or insulation was required. The calculation showed that the heat loss by convection and radiation from an uninsulated cell at 50°C would be greater than the heat generated by ohmic and overvoltage losses. Insulation, therefore, had to be provided to maintain the desired 50°C.

It was assumed that the gas lift action of the hydrogen evolved at the cathode would provide adequate agitation. Forester showed that the hypoiodite in this process is at a lower level than the hypochlorite in the chlorate process. Thus, with the large cell volume for the current used in this process versus the chlorate process, there should be no concern about too high current concentration. Current interruptions would have no forseeable effect on the product or the cell, and no special precautions were taken in this regard.

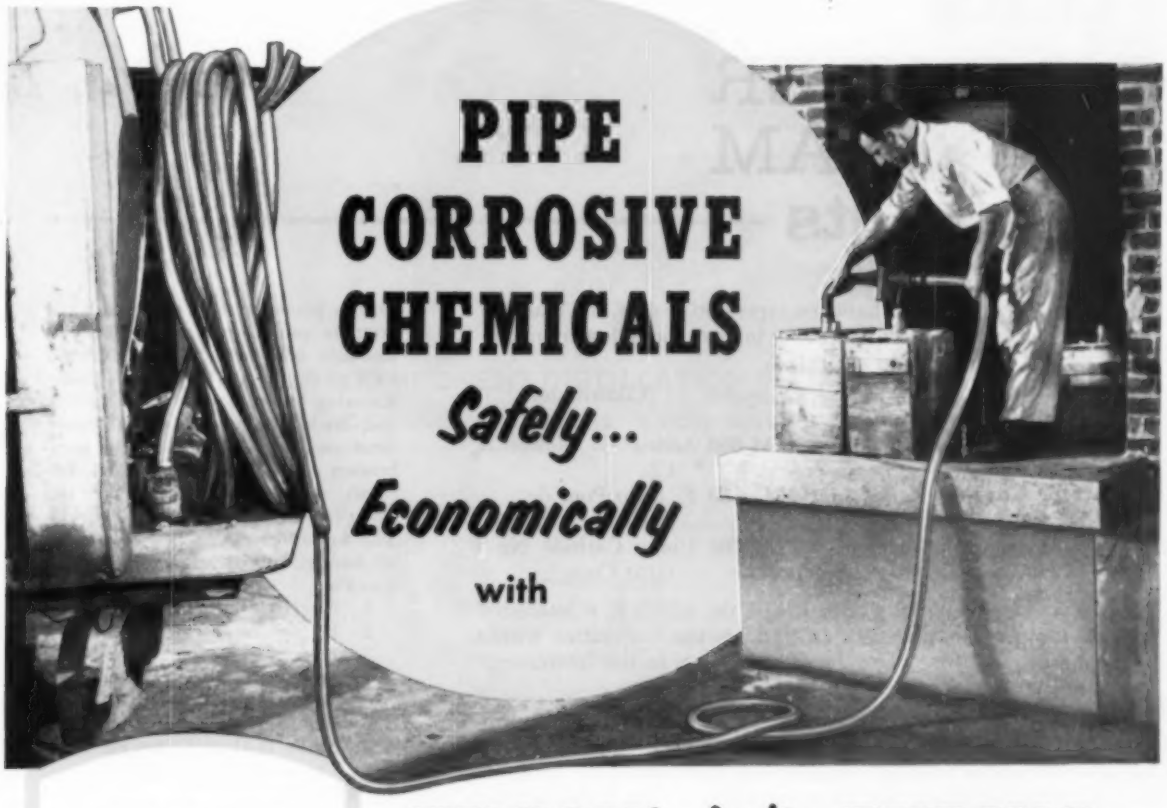
Figure 2 shows a flowsheet of the plant which was built according to desiga, started up in 1954, and has operated satisfactorily since that time. Operating data for the cells are given in Table 2, while Table 3 shows discharge potentials for the chlorine and iodine systems. It has been noted that, after five years of operation, the original graphite anodes are as good as new; this can be attributed to the low discharge potential for iodide. #

Table 2. Operating data for potassium iodate cell.

Dimensions (l x w x h)	40" x 28" x 36"
Current	500 amperes
Volts	2.20-2.25
Anodic Current Density	21 amperes per sq. ft.
Current Efficiency	94-96%
Energy Consumption	0.8 KWH/lb.
Temperature	50°C
Anode Material	AGX graphite
Cathode Material	Nickel
Cell Material	Mild Steel

Table 3. Discharge potentials for chlorine and iodine systems.

$H_2O \rightarrow O_2$	1.23 volts
$Cl^- \rightarrow Cl_2$	1.36 volts
$ClO^- \rightarrow ClO_3^- + O_2$	0.70 volts
$I^- \rightarrow I_2$	0.54 volts
$IO^- \rightarrow IO_3^- + O_2$	0.78 volts



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COMPUTER PROGRAM abstracts

Based on the interest which has been expressed to date, the Machine Computation Committee is proceeding to have the following manuals prepared, reviewed, and published.

Abstract No.	Program	Computer	Contributor
(10)	Bubble-cap Tray Design	IBM 650	Arthur G. McKee & Co.
(30)	Pressure Drop in Piping Networks	IBM 650	E. I. du Pont de Nemours & Co.
(40)	Solution of Counterflow Water Cooling Tower	IBM 704	Union Carbide Nuclear Co.

The Machine Computation Committee of the A.I.Ch.E. is interested in receiving program abstracts. Once again the Committee wishes to emphasize the three rules for participation in the interchange program:

(1) Abstracts submitted for publication must follow the form published in *CEP* (January 1959) and in the *Guide*. The submitter of the abstract agrees to make available for publication the program manual prepared along the lines suggested in the *Guide* should sufficient interest develop.

2) Abstracts must be sent to the Machine Computation Committee c/o A.I.Ch.E.

3) All questions relating to published abstracts must be sent to the Committee c/o A.I.Ch.E. in New York.

The decision on whether to have a detailed program manual prepared and published depends on the response to the corresponding abstract. Where sufficient interest has not been shown during the 1 year period after publication of a given abstract, the submitter will be released from his commitment to prepare a manual. An announcement to this effect will subsequently appear in *CEP*.

Since the first abstracts were published 2 years ago, the Committee will shortly start determining whether any manuals will definitely not be published. Consequently, those who are interested in having manuals prepared on some of these programs, but have not yet notified the Committee, should do so promptly.

Flue gas enthalpy (011)

Arthur G. McKee & Co.
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Cleveland 1, Ohio

Description: This program enables the following calculations to be made on the IBM 650 computer for the combustion of either gas fuel or oil fuel.

1. **Gas Fuel**
   - i Molecular weight of gas fuel.
   - ii Specific gravity of gas fuel.
   - iii Net heat of combustion (Btu/lb. @ 60°F).
   - iv Net heating value (Btu/SCF).
   - v Pounds of flue gas per pound of fuel.
   - vi Molecular weight of flue gas.
   - vii Composition of flue gas, mole fraction.
   - viii Flue gas enthalpy, (Btu/lb.).
2. **Oil Fuel**
   - i Pounds of flue gas per pound of fuel.
   - ii Molecular weight of flue gas.
   - iii Composition of flue gas, mole fraction.
   - iv Flue gas enthalpy, (Btu/lb.).

The enthalpy of flue gases above 60°F is calculated for a permissible temperature range of 32°F to 2700°F for various percentages of excess air. The program calculates the stoichiometric amounts of reactants and products for a given fuel and percent excess air. Knowing the composition of the flue gas, enthalpies are then calculated. Heat capacity equations of the combustion gases stored as program constants were taken from Kobe and Long (*1*).

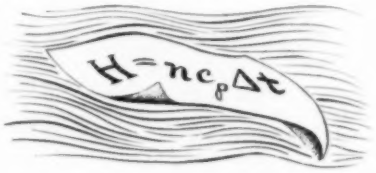
The input requirements for gas and oil fuel are shown below:

Gas Fuel

1. Percent excess air—Initial
2. Percent excess air—Delta
3. Percent excess air—Final
4. Temperature °F—Initial
5. Temperature °F—Delta
6. Temperature °F—Final
7. Moles H_2O/mole dry air
8. Chemical analysis of fuel

Oil Fuel

1. Percent excess air—Initial
2. Percent excess air—Delta
3. Percent excess air—Final
4. Temperature °F—Initial
5. Temperature °F—Delta
6. Temperature °F—Final
7. Moles H_2O/mole dry air
8. C to H Weight Ratio
9. Sulfur Weight Fraction
10. Pounds steam per pound oil



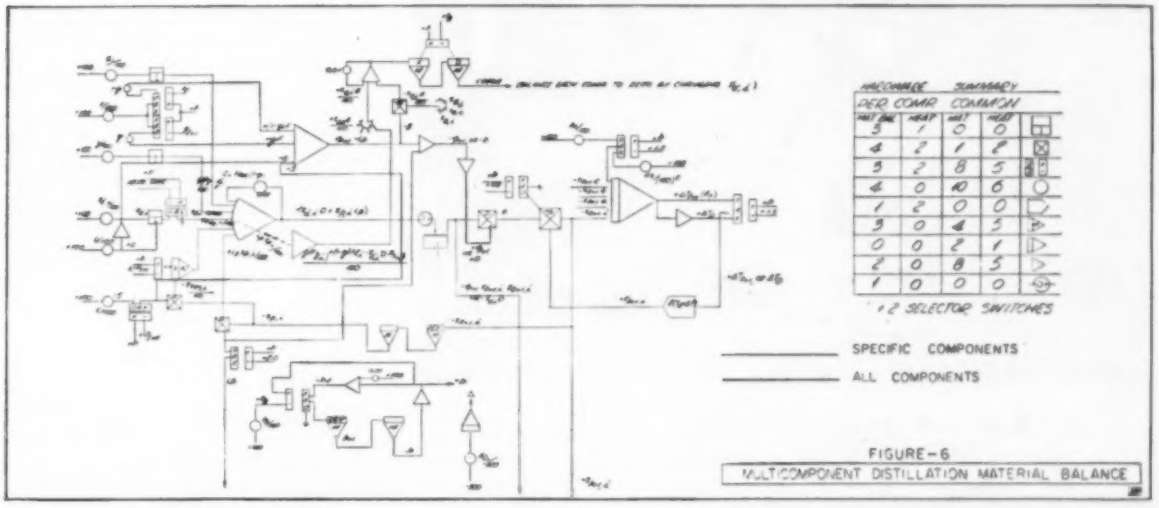
Computer: IBM 650, card input, card output with alphabetic attachments.
Program language: Bell L_2
Running time: The machine running time is variable; the minimum being two minutes.
Availability: The manual on this program can be made available for publication should sufficient interest develop.

(*1.*) *Thermochemistry for the Petroleum Industry, The Combustion Gases;* Kenneth A. Kobe and Ernest G. Long, Department of Chemical Engineering, University of Texas, Austin.

continued on page 88

HOW TO SOLVE MULTI-COMPONENT DISTILLATION PROBLEMS IN 60 SECONDS

• AUTOMATICALLY • ACCURACY TO ±0.05% • FOR ANY SET OF SPECIFICATIONS



Multi-component Distillation Material Balance.
From 13-page design report available on request.

DYSTAC* *completely obsoletes all* other methods for plate-to-plate calculations.

With DYSTAC computers you can now solve design and production problems, control limits, and optimize cost and materials! DYSTAC is truly an advancement in the state-of-the-art. Never before has there been an analog computer which combines the best features of both analog and digital machines.

Here's a partial list of just some of the applications of DYSTAC:

- Heat exchanger design
- Oil reservoir studies
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Not only can DYSTAC solve problems which were previously unsolvable, but DYSTAC is also one of the easiest analog computers to program. Offers the greatest add-on capacity. Assures minimum down time. *Guarantees* its specifications as being minimum standard under *actual operating conditions.*

For the complete 13-page design digest of the multi-component distillation problem-solution, request CSI form #80-1-5-001.

*DYnamic memory STorage Analog Computer

COMPUTER SYSTEMS, INC., Culver Road, Monmouth Junction, N. J. • DAvis 9-2351

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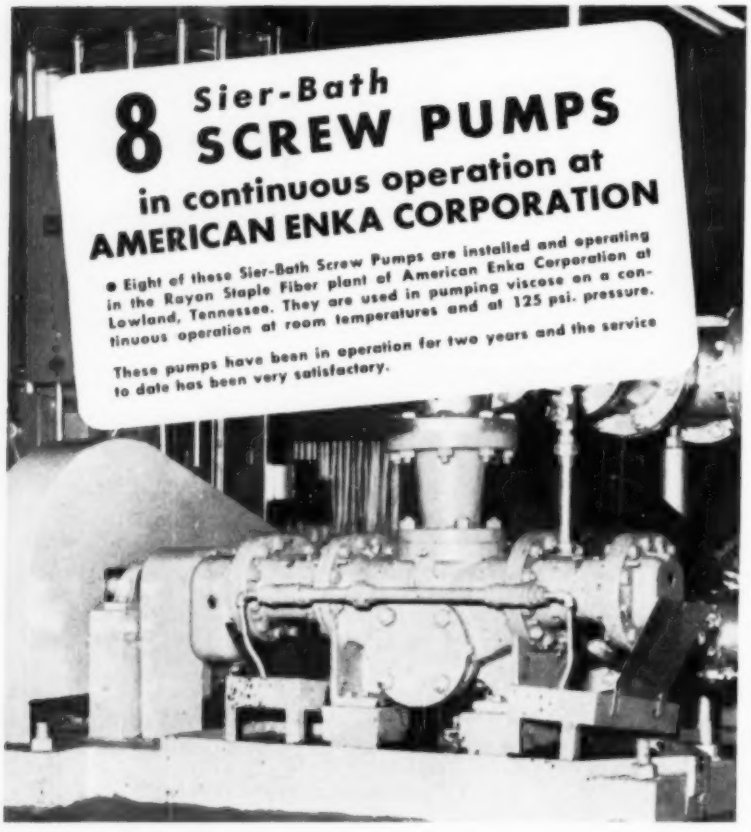
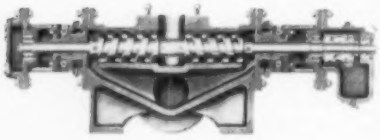
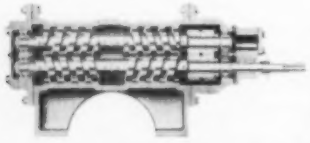
For more information, turn to Data Service card, circle No. 95


8 Sier-Bath
SCREW PUMPS
in continuous operation at
AMERICAN ENKA CORPORATION
● Eight of these Sier-Bath Screw Pumps are installed and operating in the Rayon Staple Fiber plant of American Enka Corporation at Lowland, Tennessee. They are used in pumping viscose on a continuous operation at room temperatures and at 125 psi. pressure.
These pumps have been in operation for two years and the service to date has been very satisfactory.

Sier-Bath SCREW PUMPS



External Gear and Bearing Bracket Type for non-lubricating liquids and semi-liquids



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Sier-Bath Screw Pumps maintain high volumetric efficiency because "Dual-Controlled" precision rotor design prevents rotor-to-rotor or rotor-to-casing contact—provides a continuous flow without pulsation, hammering or vibration . . . without strains, misalignment and wear on rotors, shafts, bearings and gears.

Result: Dependable, uninterrupted pumping service—less maintenance—easier servicing—longer pump life—lower overall pumping costs.

Capacities from 1 to 2,000 gpm.; viscosities from 32 SSU to 1,000,000 SSU.; discharge to 1,000 psi. for viscous liquids, 200 psi. for water and light oils. Horizontal or vertical construction. Corrosion resistant alloys, special bodies, stuffing boxes and bearings for special needs. See "Yellow Pages" for your Sier-Bath representative or write Sier-Bath Gear & Pump Co., Inc., 9272 Hudson Blvd., North Bergen, N. J.

Sier-Bath ROTARY PUMPS

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Founded 1905 | Mfrs. of Precision Gears, Rotary Pumps, Flexible Gear Couplings | Member A.G.M.A.

For more information, turn to Data Service card, circle No. 99

Computer abstracts

from page 86

Thermodynamic functions of polyatomic gases (049)

J. Gordon and R. Robinson
Reaction Motors Division,
Thiokol Chemical Corporation,
Denville, N. J.

Description: This program calculates the free-energy function, mean specific heat, entropy, heat capacity at constant pressure, and enthalpy for a pure ideal gas at 298.15°K and 300 to 6000°K at intervals of 100°K, based on the rigid rotor-harmonic oscillator assumption.

Method: Molecules may be linear or nonlinear. Input data include up to 14 different vibrational wave numbers and degeneracy of each. Einstein functions are automatically generated for the vibrational contributions. A number expressing the combined effect of molecular weight, symmetry, statistical weight of the ground state, and moments of inertia must be supplied as input.

Computer: LGP-30 or IBM-650 with 653 attachment.

Program language: SOAP IIA (Symbolic Optimal Assembly Program)

Running time: Two to five seconds per temperature depending on complexity of the molecule.

Comments: Temperature range may be varied to suit other users. About fifty molecular species have been treated with this program.

Availability: RMD Technical Report available on written request. A complete program manual can be made available for publication should sufficient interest develop.

Numerical solution for certain systems of differential equations (051)

N. E. Welch, D. S. Billingsley and C. D. Holland
Texas A & M, Dept. of Chemical Engineering College Station, Texas

Description: Using the Runge-Kutta method, this program solves the following system of equations:

$$\frac{AdW}{dZ} + \frac{CdX}{dX} + W = G \qquad (1)$$

$$\frac{dX}{dZ} = \left[exp\,(B - \frac{B}{W}) \right] (1 - X)\, f\,(X) \qquad (2)$$

continued on page 90

For more information, circle No. 42

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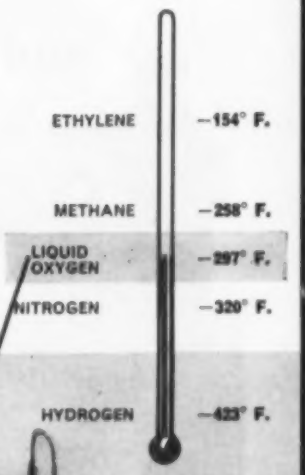
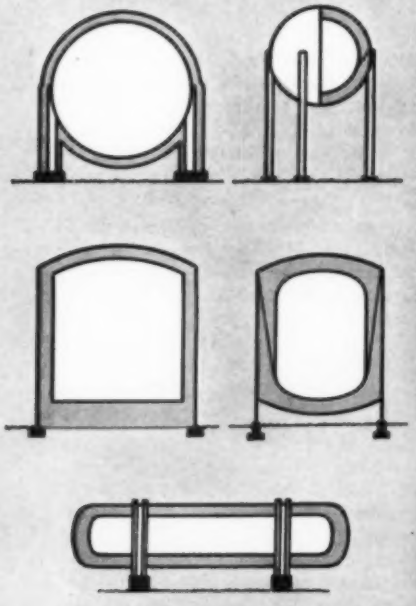


LOW TEMPERATURE STORAGE VESSELS



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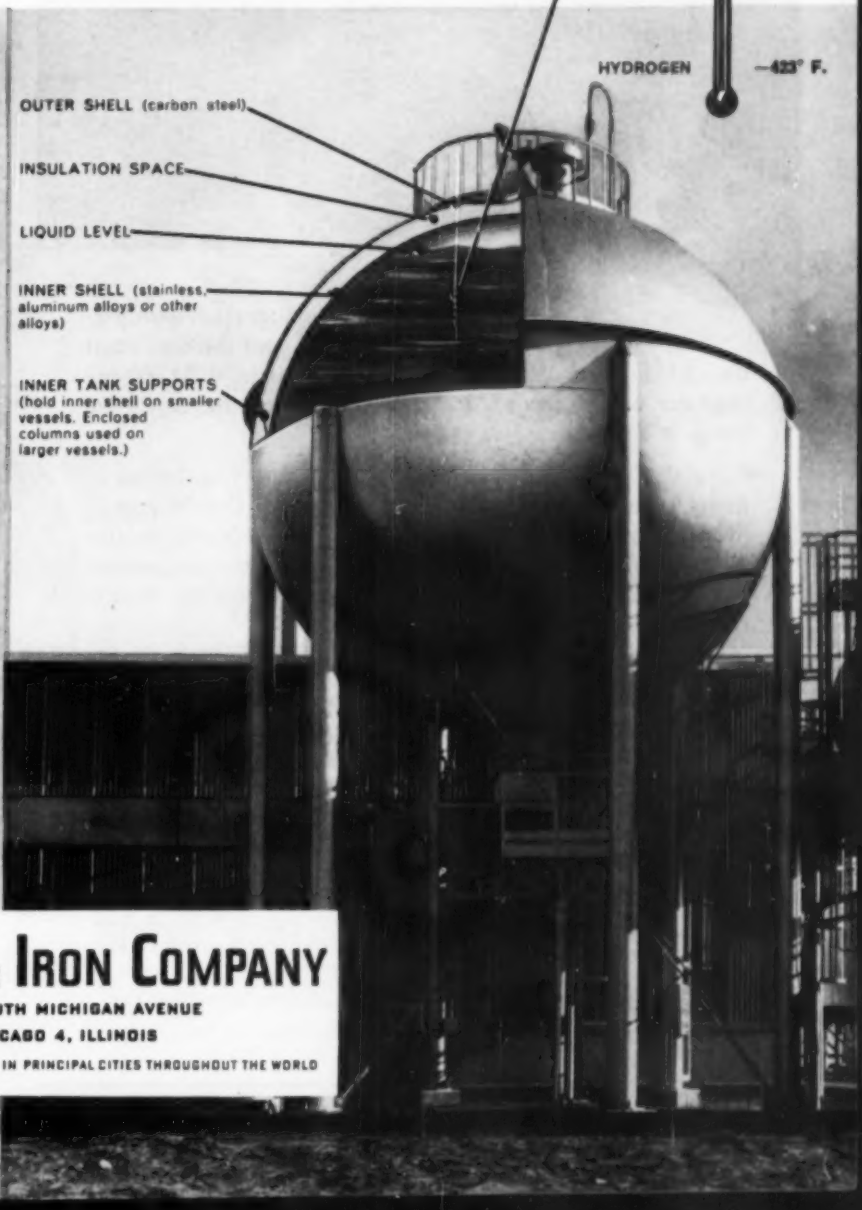
OUTER SHELL (carbon steel)
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LIQUID LEVEL
INNER SHELL (stainless, aluminum alloys or other alloys)
INNER TANK SUPPORTS (hold inner shell on smaller vessels. Enclosed columns used on larger vessels.)

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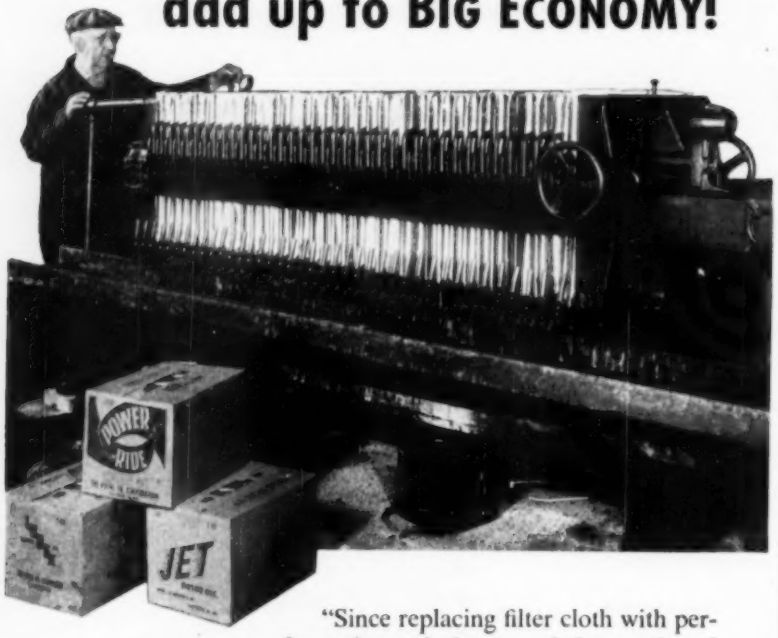
OFFICES AND SUBSIDIARIES IN PRINCIPAL CITIES THROUGHOUT THE WORLD

why E-D Filter Papers over perforated metal plates add up to BIG ECONOMY!



"Since replacing filter cloth with perforated metal plates, and the continued use of E-D Filter Papers, we anticipate a saving of $1,000 per year per press," reports A. C. Jocelyn, President, Royal Oil Corp. of Baltimore.

Royal Oil's experience and future planning are typical of many manufacturers who report that clean, new E-D filter papers over perforated metal plates save money by reducing the unfiltered product retained in filter cloth. E-D papers also provide a definite and dependable "openess" every time the filter is redressed.

In addition, E-D Filter Papers on perforated metal plates permit a lower over-all pressure drop throughout the filter. Finally, because they are easier to change, E-D Paper Filters mean a substantial saving in downtime.

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E D

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"First with Filter Paper exclusively."

For more information, turn to Data Service card, circle No. 57

Computer abstracts

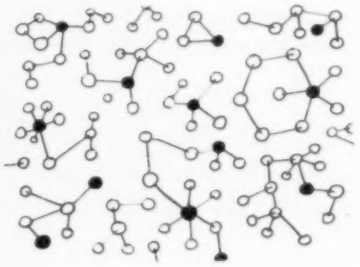
from page 88

where $f(X)$ has one of the following three forms

$f(X) = 1$
$f(X) = (1 - X)$
$f(X) = [1 - Y(1 + X)]$
and where $0 \leqq X < (1 - Y)/Y$;
$0 < W \leqq G$; $X < 1$

Restrictions on the parameters A, B, C, G, and Y are discussed below.

This system of equations with $f(X) = 1$ has been used by Billingsley, *et. al.* (*1*), to describe certain systems



involving the first order reaction $A \rightarrow$ Products. Similar systems involving the second order reaction $2A \rightarrow$ Products or $A + B \rightarrow$ Products may be described by this set of equations when $f(X) = [(1 - X)]$ or $f(X) = [1 - Y(1 + X)]$ respectively.

Since all computations are in fixed point, arithmetic overflows in the accumulator should be expected when data do not lie within the following limits.

$$\begin{array}{rcl} 0 & \leqq & C \leqq 0.18 \\ 0.005 & \leqq & A \leqq 0.111 \\ 5 & \leqq & B \leqq 55 \\ 1.02 & \leqq & G \leqq 1.18 \\ 0 & < & Y < 1.0 \end{array}$$

Among other ways, the program was checked using $f(X) = 1$ and combinations of the above limits which appeared most likely to result in overflows. These limits were used since they were the ones of interest in the preparation of (*1*). It is entirely possible that the program will handle certain problems where the data exceed some of these limits.

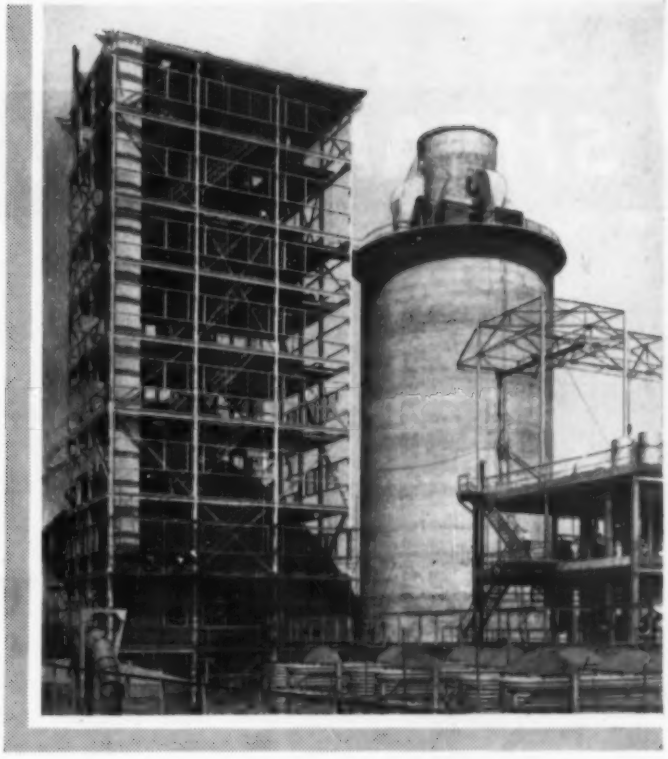
Computer: IBM 650, no accessories other than the read-punch unit. 1000 word drum. The program occupies locations 0000-0354.

Program language: Soap I

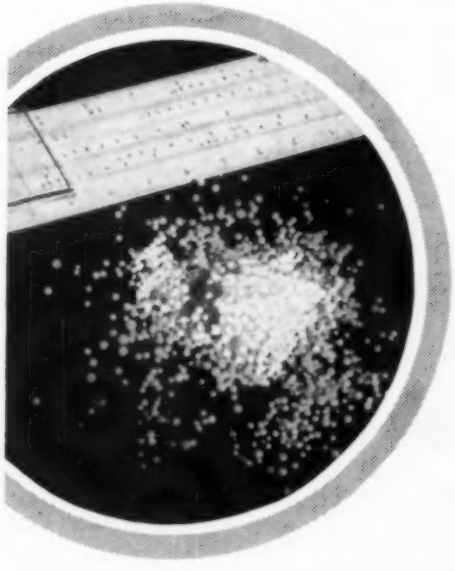
Running time: Approximately 7 minutes for a problem where $f(X) = 1$, $\Delta X = 0.01$ and the initial value of X is zero.

continued on page 92

Urea plant at Modderfontein, South Africa, during erecting



300 tons of Urea per day



This high capacity Urea plant is constructed and erected by Werkspoor to the designs of Stamicarbon-Holland. Werkspoor is fully qualified to supply the following plants:

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4. Nitrophosphate (starting from raw phosphate, nitric acid and ammonia)
5. Calcium nitrate (starting from limestone and nitric acid)
6. Sulphate of ammonium (starting from ammonia and sulphuric acid)
7. Urea (starting from liquid ammonia and carbon dioxide)

WERKSPOOR

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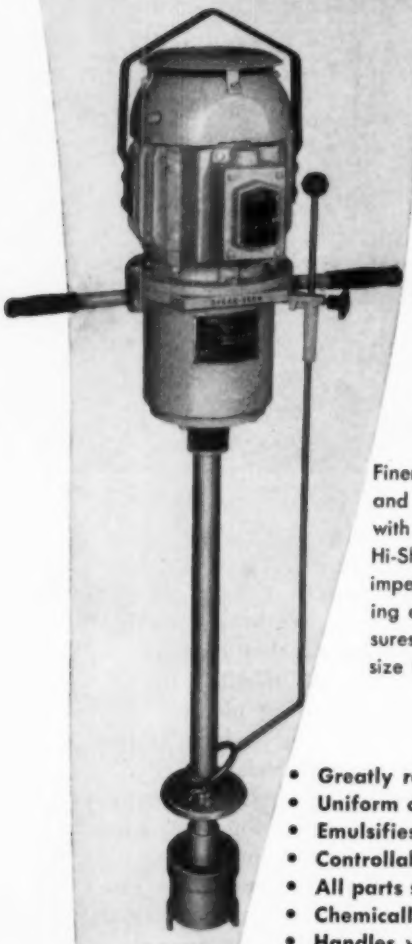
For more information, turn to Data Service card, circle No. 22

SHEAR-FLOW



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Finer, faster blending, dispersing and homogenizing is now possible with Shear-Flow's new Model RL Hi-Shear Head. Finely spaced dual impellers induce considerable shearing action and high pumping pressures that rapidly reduce particle size for superior material mixtures.

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- **Controllable flow pattern**
- **All parts stainless steel**
- **Chemically inert seals**
- **Handles viscous materials with ease**
- **No operating Torque**
- **Disperses, blends, homogenizes**

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For more information, turn to Data Service card, circle No. 81

Computer abstracts

from page 90

Availability: A limited supply of copies of the program are available and may be obtained from the Data Processing Center, Texas Engineering Experiment Station, College Station, Texas, by requesting Program No. A.M. 940.

A complete program manual written to A.I.Ch.E. standards as indicated in the "Guide to Abstracts and Manuals for Computer Program Interchange" will also be made available should sufficient interest develop.

(1) Billingsley, D. S., McLaughlin, W. S., Welch, N. E., Holland, C. D., *Ind. and Eng. Chem.*, *50*, 741-752 (1958).

Machine Computation Committee
A.I.Ch.E.
25 West 45th Street
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I am interested in computer program manuals corresponding to the following abstracts:

☐ **(011) Flue gas enthalpy**

☐ **(049) Thermodynamic functions of polyatomic gases**

☐ **(051) Numerical solution for certain systems of differential equations**

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TOP: *Muddy well water is the coolant for these Jacket Water Coolers.*

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industrial news

New slant on cooling tower treatment

Long-term tests by Dow Chemical prove algae-control, wood-protection effectiveness of non-oxidizing chemicals

Cooling towers at Dow Chemical, Freeport, Texas.

NON-OXIDIZING CHEMICALS, such as sodium pentachlorophenate or commercial formulations containing blended chlorophenates, have demonstrated superior properties in cooling tower protection and control of algae and slime. Tests carried out by Dow Chemical at its styrene plant in Freeport, Texas, cover a period of some fifteen years of cooling tower experience, including special testing programs in 1949 and 1958.

The cooling system used by Dow at Freeport serves the styrene plant heat exchangers. It contains a total of about 2 million gallons of water with a daily circulation of 100 million gallons and an average water makeup of 1,700,000 gallons/day.

At the start of operations in 1943, chlorine was used for biological control. However, algae control was difficult, and mist eliminators required hand cleaning at least once a year. "Chemical white deterioration" (delignification) also proved to be a problem. Characterized by softened wood with a bleached appearance, the condition is thought due to chlorolignin formation. When alkalinity is high and excessive amounts of chlorine are used, the chlorine can react with the lignin in the wood, and the wood quickly deterioriates due to separation of the cellulose fibers. The Dow study indicated that even a low concentration of chlorine can initiate surface deterioriation of wood.

Sodium pentachlorophenate treatment

Second phase of the study was started in 1948, when the entire cooling system was cleaned and sodium pentachlorophenate was circulated at 80 ppm. Within 24 hours after start of treatment, all signs of algae disappeared where direct water contact was made. Main advantages of sodium pentachlorophenate over chlorine were found to be:

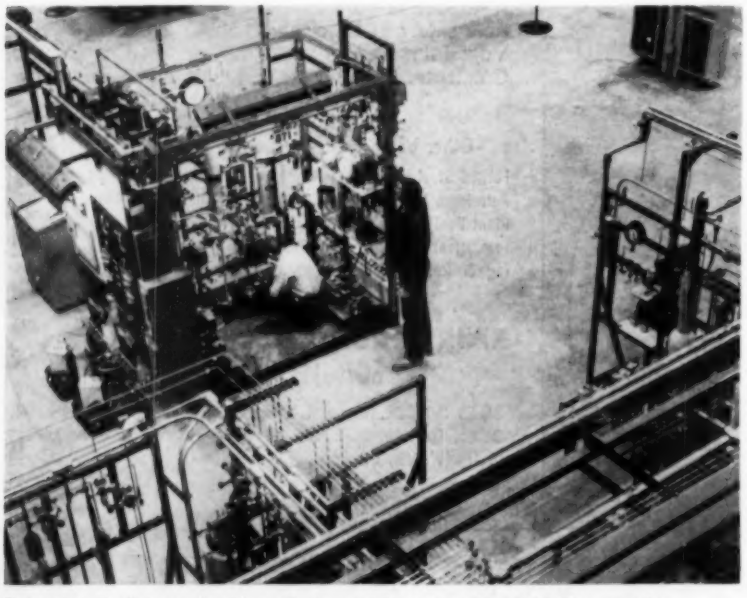
- Lower net cost;
- More thorough job of cleaning;
- Actual surface protection for wood instead of a delignification hazard.

Tests started in 1958 had a double objective. First—"to determine if a tower thoroughly fouled with algae and slime could effectively be brought under control with a heavy shock treatment of biocide, and then maintained in good condition for an extended period by administering intermittent lighter dosages." Second—"to determine if the basic biological activity of sodium pentachlorophenate could be increased further by formulations which would aid penetration of sodium pentachlorophenate into the accumulated biological growth."

Positive conclusions

Results of a large-scale testing program at Freeport showed that:

- Either sodium pentachlorophenate or commercial products containing blended chlorophenates may be used successfully. It is apparent that the effective biocidal activity is derived from the presence of chlorophenate;
- The formulated product containing blended chlorophenols had a detergent effect and was more effective in the control of algae and slime.



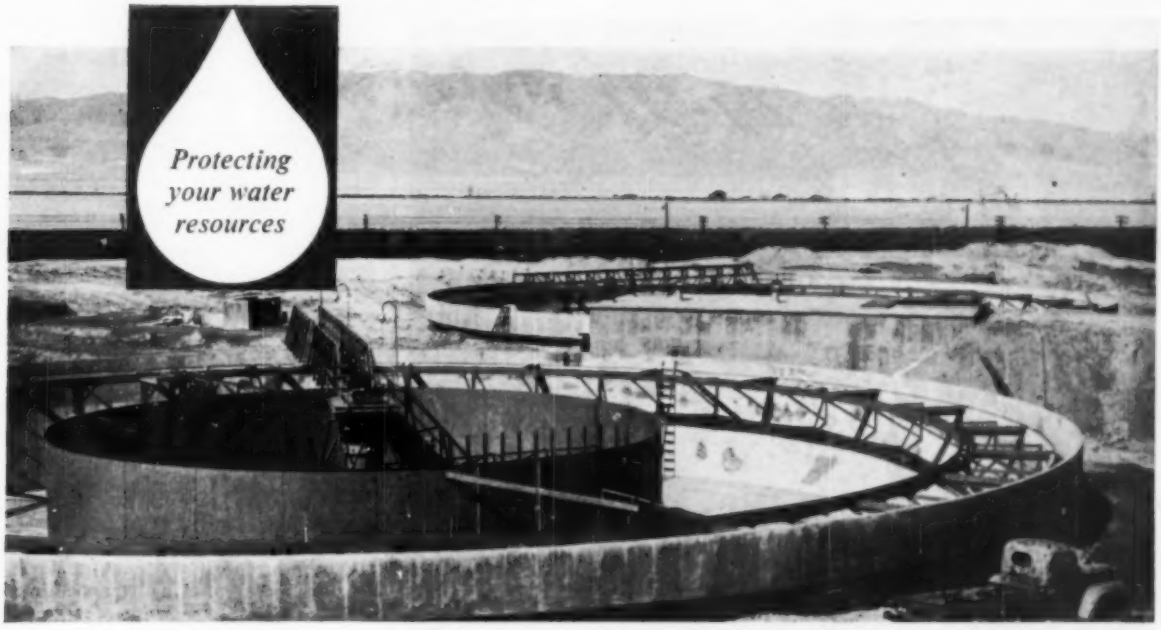
Esso R & E pilot plant with control panel tied in to the LGP-30 computer.

Computer Control —the facts of life

L. A. Symposium gives the low-down on automation of pilot plants — potential advantages, pitfalls, bottlenecks.

SEPARATION OF SCIENCE and engineering in the curricula of most engineering schools can be a definite obstacle in the path of students in the new "hybrid" field of instrumentation and automation. The point was brought out in a panel discussion at the recent Symposium on Pilot Plant Automation, held in Los Angeles. Sponsored jointly by Consolidated Systems Corp., Daystrom, and Thompson-Ramo-Woold-

continued on page 96



At Columbia-Geneva ... *Eimco-Process treatment system purifies waste water for reuse, recovers valuable mill scale*

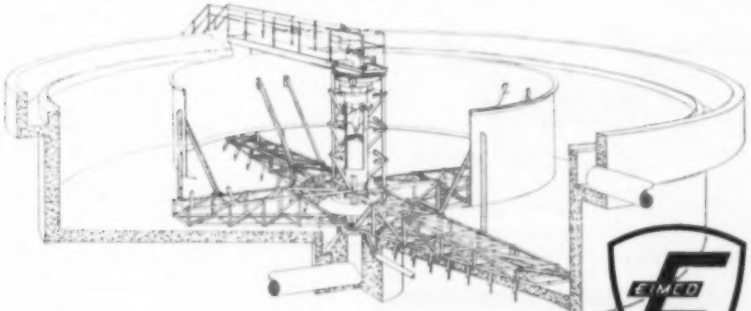
Water is a vital raw material in steelmaking, and at U. S. Steel's big Geneva works, enough water is circulated through the plant each day to float a dozen ships the size of the Queen Mary. Most of the millions of gallons circulated are reclaimed and used over and over again.

To help meet the demands for cleaner water created by rising steel capacity and product quality improvements, the Columbia-Geneva Steel Division uses a system in which two 135 ft. dia. Eimco-Process Reactor-Clarifiers are the key elements. Together, the units will ultimately handle an average flow of 30 MGD.

In operation, used water from the rolling mills is pumped to the treatment plant for addition of alum and a coagulant aid. The water then passes into reaction compartments in the Reactor-Clarifiers where the floc is built up by recirculation. Solids settle out and are moved to the tank centers by rotating rakes. These solids, primarily mill scale, are collected in recovery ponds for return to the steelmaking process as a raw material.

In the clarification process, quantities of oil are skimmed from the surface and the clarified water is continuously recycled through the plant.

The careful conservation and use of water is of top priority at Columbia-Geneva and Eimco-Process is proud to have its equipment helping make high quality steel. For information on how an Eimco-Process waste water recovery system can perform a similar valuable service for you, please contact any of our nationwide sales representatives.



Reactor-Clarifier of the type installed at United States Steel Corporation's Columbia-Geneva Steel Division plant near Provo, Utah.

THE EIMCO CORPORATION

Process Engineers Division

420 Peninsular Avenue,
San Mateo, California

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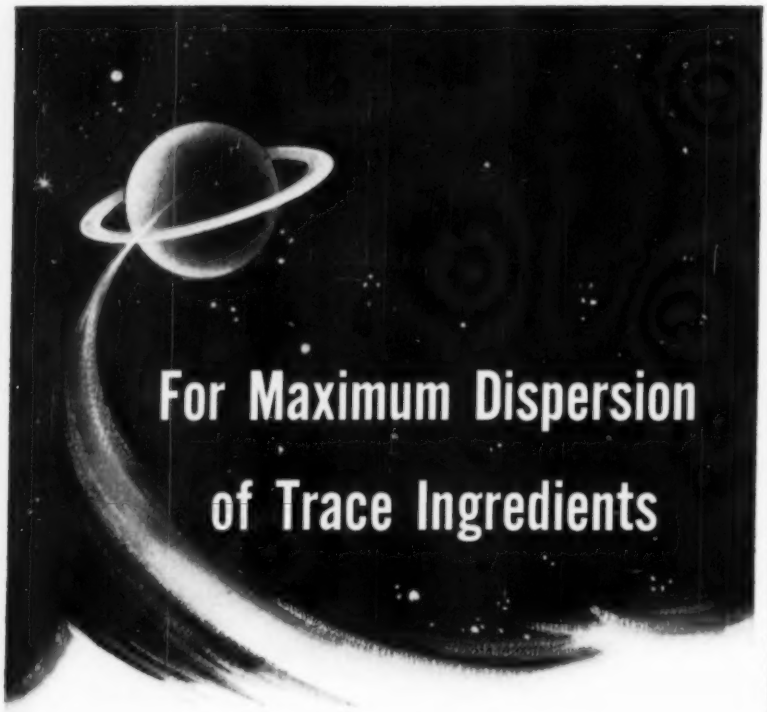
For more information, turn to Data Service card, circle No. 100



High intensity mixing for the thorough and constant dispersion of trace ingredients . . . Dispersions with the Entoleter Impact Mill utilizing BASIC CENTRIFUGAL FORCE are complete and uniform within the closest tolerances in both batch and continuous processing of dry materials and aqueous suspensions.

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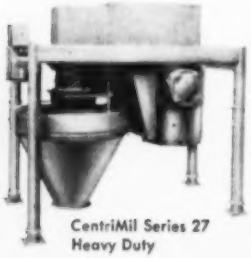
- Dispersion of dye in cement
- Dispersion of high potency insecticides in bulk mixtures
- Color dispersion in household detergents
- Thorough mixing of additives in prepared foods
- Intimate blending of pigments in dry paint, plastics, etc.



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For more information, turn to Data Service card, circle No. 55

Computer control

from page 94

ridge, the symposium brought together managers and experts from 60 chemical, petrochemical, and petroleum refining companies interested in automating processes.

Notable exceptions to the rule are Case Institute of Technology in Cleveland, and the University of Arkansas, which have both taken definite steps to create integrated graduate-level courses in the new science of instrumentation.

Hardware hurdles

Trained personnel is not the only bottleneck in development of automatic instrumentation—hardware can also be a headache. One present need, pinpointed at Los Angeles, is a practical transducer for pilot plant use. Such a transducer must be compact and self-contained, yet accurate and precise. Its signal output must be compatible with the input requirements of available data-processing systems. It must be highly reliable, but low in cost.

A suitable transducer can lower costs and improve data. Gas mass flow measurement, for example, requires at least three measurements when made conventionally.

Typical overall precision is on the order of plus or minus 4%. Comments from the floor at L. A., however, suggested that several mass flow devices with plus or minus 0.1% precision will be on the market within a year.

Analyzers

Of available devices, the process chromatograph meets best the special requirements for analysis instrumentation: versatility, high accuracy, wide calibration range, continuous process-type design. To the chromatograph can be added simple computaton devices to process the analytical data and provide signals for actual closed-loop control of pilot plant operation. Problem remaining to be solved satisfactorily—an information-gathering element for processes involving the handling of solids.

Where does the computer fit in?

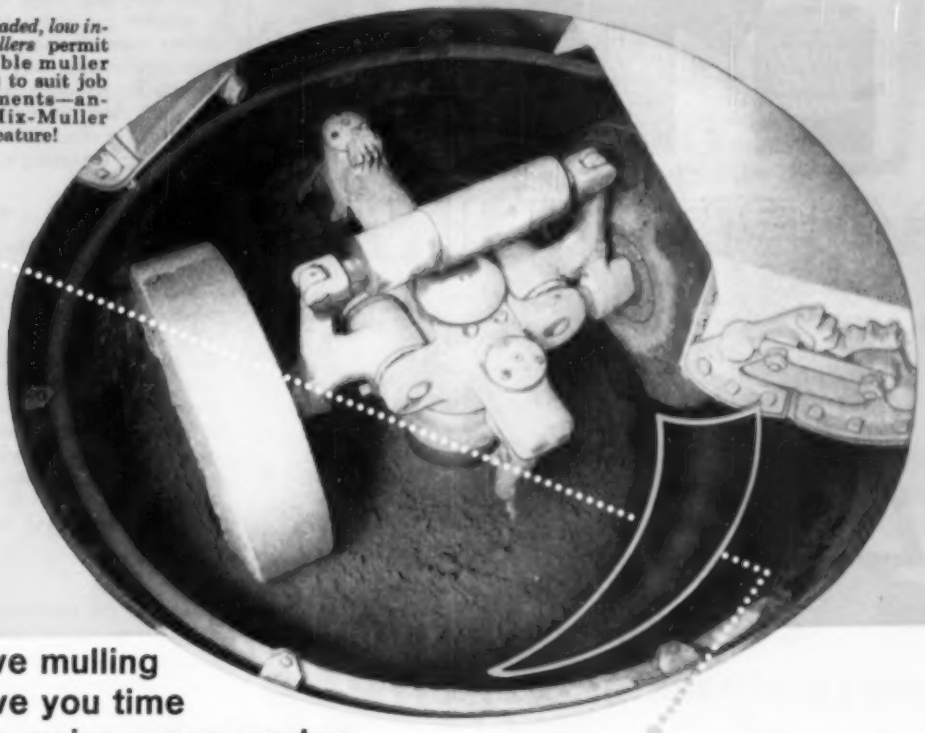
Opinions at Los Angeles differed widely on the economic value to be derived from computer control of pilot plants. Full-scale automation of petroleum industry pilot plants appears to be practical. Because of the similarity in physical equipment between numerous processes, the automated pilot plants can have "repeat-use" value. In

continued on page 98

MIX-MULLER®

MEANS CONTROLLED DISPERSION FOR DRY SOLIDS:

Spring loaded, low inertia mullers **permit adjustable muller pressures to suit job requirements—another Mix-Muller control feature!**



Intensive mulling can save you time and expensive reprocessing

The Simpson Mix-Muller is specifically designed to put *you* in control of mixed properties. In this era of expensive, high purity materials such a machine can, in one operation, help you eliminate reprocessing, remixing and slash waste and rejects simply by making the *most* of prepared ingredients.

For these reasons, the rapid increase in the use of the Simpson Mix-Muller has paralleled the increasing availability of better, more uniform and more *expensive* raw materials.

For similar reasons . . . Mix-Muller usage has paralleled a new, enlightened attitude on mixing practice among processors who have learned that careful attention to mixing operations can be their most important source for *savings*.

Can you *afford* to settle for less than controlled dispersion?

See our advertisement: CHEMICAL ENGINEERING CATALOG

SIMPSON *MIX-MULLER*® DIVISION

National Engineering Company

652 Machinery Hall Bldg. • Chicago, Illinois

3 way mulling action coats each grain

. . . KNEADING

Because the mullers never touch the wearplate, you get an intensive kneading of the muller against material grains—through a deep bed of material.

. . . SMEARING

The inside edges of the wheel have a shorter distance to travel than the outside edges to provide a smearing action—across the wide face of the mullers.

SPATULATE ACTION

...Note that mullers are set slightly off true radius so that as they roll they also skid sidewards to provide a spatulate action.

. . . THIS IS CONTROLLED DISPERSION

WRITE FOR HANDBOOK

—on mulling. 12-page bulletin explains controlled dispersion—gives details on 9 Mix-Muller models (¼ to 60 cu. ft. batch capacity).

For more information, turn to Data Service card, circle No. 65

a wide range of

MAINTENANCE COATINGS

that will save you money!

What do *your* corrosion conditions require? This, in brief, is Carboline's approach to *each* maintenance problem: a service-proven coating engineered to a specific condition.

From our broad line of experienced maintenance coatings, we have a separate, correct system to match each condition—not one or two "cure-all" systems to fit *all* environments. It is this engineering approach that reduces maintenance costs and assures maximum economy.

Carboline coatings are higher in solids content, which produces greater film build-up and requires fewer coats—reducing labor costs. Superior quality results in longer life and requires fewer recoating cycles—again reducing labor costs. That's why Carboline coatings are *in*expensive and give you better protection, too.

May we have the opportunity to bid your next job? We'll prove we can reduce your maintenance costs.

WRITE TODAY, meanwhile, for Maintenance Chart No. 5 with complete details on 17 different maintenance systems.

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Sales engineers in principal cities. Consult your telephone directory.

MAINTENANCE COATINGS WITH EXPERIENCE

For more information, turn to Data Service card, circle No. 94

Computer control

from page 96

the chemical industry, on the other hand, because of wide differences between processes, it may not always be economically feasible to automate fully.

Possible optimum use of pilot plant plant computers may, in some cases, be in batch processes, rather than continuous ones. Reason—computers, by their very nature, may be considered as tools for handling transient conditions, are therefore suitable for application where conditions change rapidly, and where complex calculations are required.

By-product benefits

The technical studies which must precede consideration of computer control, said one of the panelists, are extremely valuable in that they force more careful and complete thinking about chemical processes and their mechanisms. Corrollary—This additional thinking may frequently result in less expensive or more profitable alternatives than on-line computer control. In some cases, rapid on-line information acquisition, a prerequisite for computer control, may be all that is needed.

Trends

Here is the consensus of the L.A. Symposium:

- General-purpose computers will be used increasingly in process control systems. This will result in design of computers larger and faster than those presently available;
- There will be an attempt to handle small problems by providing special-purpose equipment (digital, analog, or hybrid) using the techniques originally developed for larger, more expensive systems;
- Systems-oriented companies will be forced more and more into development of special transducers and analyzers.

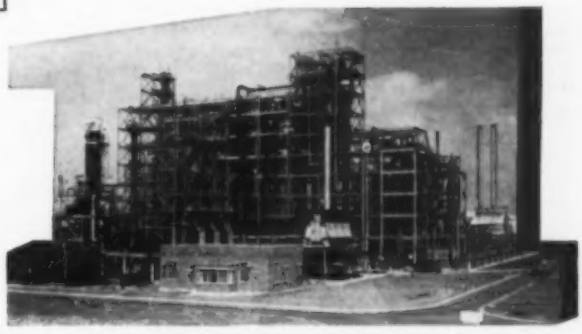
Another move in Koppers polystyrene plastic expansion policy is an increase in facilities at the Kobuta, Pa., plant, amounting to 15 percent.

The newly finished Food Machinery and Chemical Research and Development Center at Princeton, N.J., contains a specially designed area for pilot scale studies in textiles, pulp and paper, detergents, metals and other fields. Other work going on at the center is in polymer applications and functional fluids, and general analytical work.

KELLOGG BUILDS FOR I.C.I. EXPANSION

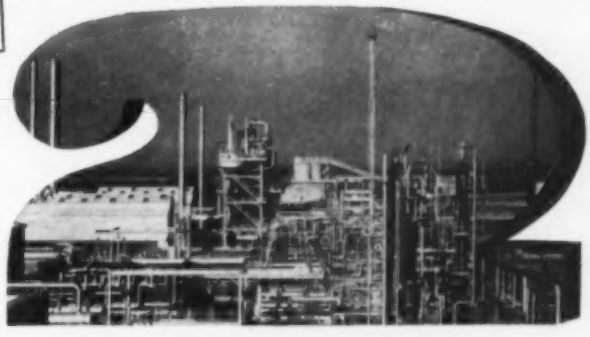
1951

Recent completion of Imperial Chemical Industries' third olefin plant at Wilton, England, has made these Works the largest petrochemical venture outside the United States. With a current output of 110,000 tons per year of high-purity ethylene, and a potential output of 140,000 tons, I.C.I. Wilton is an outstanding example of engineering cooperation.



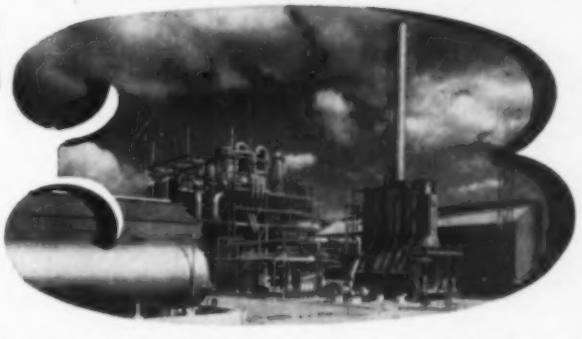
1956

The first plant was commissioned in 1951, and was the first full-scale adoption of the then novel process of oil pyrolysis developed in the Kellogg Laboratories. Its success led to the addition of No. 2 plant in 1956, and then to this latest extension, representing a 60% increase in olefin capacity, in 1959.



1959

Cooperation between client and contractor is the keynote of Kellogg's contribution to chemical engineering. The Wilton Olefin Plant is the largest in the world based on liquid feedstock. Kellogg is proud to have been associated with its development.



To learn more about Kellogg's background in engineering and building olefin plants, at home and overseas, write for current Kelloggram

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For more information, turn to Data Service card, circle No. 21

FACTS FIGURES AND IDEAS FROM BOWEN ENGINEERING, INC.

Spray drying NEWS

VOLUME 2, NO. 3

RECOGNIZED LEADER IN SPRAY DRYING SINCE 1926

SPEAKING FOR BOWEN

HARMAN D. DUMONT, *Bowen specialist in small-scale test work, answers questions of interest to new product researchers.*

Q: Can special chemical or pharmaceutical products like those referred to in the adjoining article be spray dried experimentally without our becoming involved in expensive tests using commercial-scale spray drying equipment?

A: Yes. The BOWEN LABORATORY SPRAY DRYER was developed with exactly that purpose in mind. This versatile, research-size unit features the same basic operational characteristics of large, conical-bottom production spray dryers. It permits fast, qualitative evaluation of spray drying in connection with new product and new process development work. A few short, inexpensive tests using just a few gallons of material usually will indicate whether or not spray drying can be of benefit to you.

Q: Where can I have small-scale, exploratory tests of this kind carried out?

A: The BOWEN TEST LABORATORY offers this service. Tests can be conducted with the Bowen Laboratory Spray Dryer using both centrifugal and nozzle atomization to determine which atomization method is the more suitable and a variety of samples can be produced for your evaluation. Of course, in such test work, you benefit, too, from the specialized knowledge and skills we have acquired during our many years of running tests with a multitude of different products.

Q: Can I purchase a Bowen Laboratory Spray Dryer so that spray drying can be explored as a matter of standard practice in all new product development work right in our own laboratory?

A: Yes, indeed. Hundreds of these units have been sold to universities, research institutions and industrial laboratories throughout the world. In addition, this small dryer has proven to be an ideal small-lot production unit and is used widely for this purpose in certain pharmaceutical, ceramic and low-volume chemical specialty fields.

Check items desired, clip and mail with your name, title and company address to Bowen Engineering, Inc., North Branch 13, N. J.

☐ Editorial Reprint EL

☐ Laboratory Spray Dryer Bulletin 34

Information on the feasibility of spray drying:

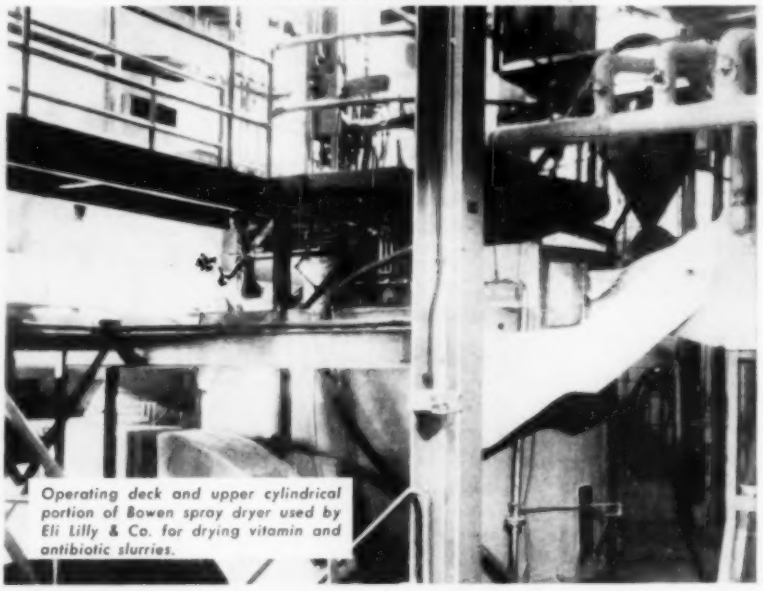
_____

_____

BOWEN ENGINEERING, INC.
North Branch 13, N. J.

Potency of Heat-Sensitive Drugs Safeguarded by Spray Drying Process

Eli Lilly & Co. Uses Bowen Spray Dryer In Vitamin and Antibiotic Production



Operating deck and upper cylindrical portion of Bowen spray dryer used by Eli Lilly & Co. for drying vitamin and antibiotic slurries.

Whenever minimum drying temperature and short residence time in the dryer are vital considerations in selecting the most suitable drying method for a difficult drying problem, spray drying always rates a top place among methods earmarked for serious evaluation. Take the case of Eli Lilly & Company for example:

Over ten years ago, the engineers of Lilly's Glandular Products Division thoroughly explored the spray drying process in their efforts to better insure the uniformity, consistency and full potency of certain pharmaceutical products. In 1949, following extensive test work in the Bowen Test Laboratory and close collaboration between Bowen and Lilly engineers, a specially-engineered Bowen spray dryer was installed for drying a variety of vitamin and antibiotic slurries containing extremely heat sensitive ingredients.

DRYING TIME MEASURED IN SECONDS—Because spray dried materials never reach the temperature of the dryer inlet air (due to immediate evaporative cooling effect)—and because total elapsed time from slurry introduction to dry product collection is only a matter of seconds—spray drying answered Lilly's problem of providing insurance against product degradation and loss of potency during processing.

COSTLY PROCESS STEPS ELIMINATED—Furthermore, as is so frequently the case when spray drying is integrated into a processing operation, certain formerly-required process steps (as double filtering and drying) were eliminated, resulting in savings in time and processing costs.

BOWEN SPRAY MACHINE PLAYS KEY ROLE—The Bowen dryer used in Lilly operations is of conical-bottom design. The upper cylindrical portion of the drying chamber is 10 feet in diameter. Proper atomization of the various vitamin and antibiotic slurries is accomplished by a ruggedly-constructed Bowen Spray Machine driving a multi-vaned centrifugal atomizer wheel at speeds of 10,000 to 14,000 rpm depending upon atomization characteristics desired.

Spray dryer capacity is rated at 20 tons per 24-hour day. The great bulk of product is collected in the first of two cyclone collectors and is carried by a jacketed, liquid-cooled screw conveyor to packaging or storage points.

For more details on this installation, request Editorial Reprint EL.

For more information, turn to Data Service card, circle No. 134

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SUBJECT GUIDE to advertised products

EQUIPMENT

Anodes, graphite (p. 11). Brochure from Great Lakes Carbon gives tables of standard sizes and grades of square and rectangular anodes. **Circle 34.**

Burst Discs, graphite (p. 150). Standard sizes 1 to 8 in., burst pressure ratings 1 to 400 lb./sq. in., temperatures to 650° F. Technical data and Price Schedule from Kearney Industries. **Circle 84.**

Can Coder (p. 159). Data from J. M. Lehmann on automatic can and package coding machine. Sixty cans per minute. **Circle 60.**

Centrifugals (p. 23). Bowl diameters from 6 to 54 in., separating forces from 30 to 3,000 gs. Info from Bird Machine. **Circle 148.**

Centrifuges, pressure (p. 6-7). Complete details on the "Merco" centrifuge from Dorr-Oliver. **Circle 111.**

Classifiers, air (p. 28). Bulletin AH-467-40 from Hardinge gives complete specifications of the "Gyrotor" air classifier system. **Circle 71.**

Compressors (p. 103). From single to six stages, from 125 to 42,000 lb./sq. in. pressure, for full range of gases. Info from Norwalk Co. **Circle 61.**

Compressors (p. 112-113). Bulletin, "Cooper-Bessemer Equipment for Chemical Plants," gives full technical details. **Circle 32.**

continued on page 102

MATERIALS

Coatings, protective (p. 98). Maintenance Chart No. 5 from Carboline gives complete details on 17 different maintenance systems. **Circle 94.**

Defoamers, silicone (p. 9). Technical data and free samples available from Dow Corning. **Circle 1.**

Desiccants (p. 121). Data from Johns-Manville, Celite Div., on "Micro-Cel" synthetic calcium silicates. **Circle 96.**

Fluorine (p. 133). Bulletin from Matheson gives technical data, handling procedures. **Circle 72-3.**

Gases, compressed (p. 133). New Catalog from Matheson has prices and data on 85 compressed gases and mixtures. **Circle 72-1.**

Gases, process (p. 115). Facilities for supply of tonnage quantities of oxygen, nitrogen, hydrogen, helium, argon, other process gases. Info from Air Products. **Circle 5.**

Heat Transfer Cement (p. 165). Nonmetallic adhesive with efficient heat transfer properties. Bulletin 300 from Thermon Mfg. **Circle 25.**

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ERVICES

sign and Construction, low-tempera-re gas separation plants (p. 143). fo from American Air Liquide on low-mperature processes and equipment. **rcle 77.**

sign and Construction, olefin plants 99). Data on three olefin plants ilt by M. W. Kellogg for Imperial emical Industries. **Circle 21.**

sign and Construction, process nts (p. 31). Data from Ralph M. rsons on world-wide design, engi-ering, construction services. **Circle 6.**

sign and Construction, process nts (p. 91). Data from Werkspoor etherlands) on facilities for supply of nts for ammonia, nitric acid, nitro-osphate, calcium nitrate, ammonium lfate, urea. **Circle 22.**

brication, process equipment (p. 34). fo from Boardman Co. on its facili-s for design and fabrication. **Circle 4.**

brication, process equipment (p. 1). Technical data from Charles Ross Son on many types of mixing and nding equipment. **Circle 135.**

brication, process equipment (p. C). Technical info from Wyatt Indus-es, Wyatt Metal & Boiler Works Div. **rcle 40.**

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CEP'S DATA SERVICE—Subject
CIRCLE C

EQUIPMENT *from page 101*

Computer, analog (p. 87). Computer Systems, maker of DYSTAC analog computer, offers 13-page design digest of multi-component distillation problem solution (CSI form 80-1-5-001). **Circle 95.**

Controls, liquid-level (p. 161). For all types of liquids, horizontal, vertical, external mountings. Info from Jo-Bell Products on the "Level Master." **Circle 62.**

Controls, visual (p. 175). Booklet BE-50 from Graphic Systems. **Circle 82.**

Conveyors (p. 157). New 88-page Conveyor Data Book from Continental Conveyor & Equipment. **Circle 27.**

Conveyors, closed-belt (p. 21). Bulletin 349 from Stephens-Adamson Mfg. describes Zipper-type conveyor elevators. **Circle 47.**

Crushers, jaw (p. 151). Capacities to 30 ton/hour. Bulletin 062 from Sturtevant Mill. **Circle 8-1.**

Crushers, rotary fine (p. 151). Reduce soft to medium hard 3 to 8 in. material down to ¼ to 1¼ in. sizes. Bulletin 063 from Sturtevant Mill. **Circle 8-2.**

Cryogenic Equipment (p. 153). Technical data from Ryan Industries, Cryogenic Dept. **Circle 17.**

Deionizer (p. 165). Data from Elgin Softener on new Junior 120 Deionizer. **Circle 45.**

Dryers (p. 147). Info from C.G. Sargent's Sons on dryers, coolers, feeders, extruders, granulators. **Circle 46.**

Dryers, fluidized-bed (p. 109). Data from General American Transportation on new fluidized-bed drying-cooling system. **Circle 33.**

Dryers, spray (p. 100). Bowen Engineering offers Editorial Report EL on spray dryer in vitamin and antibiotic production, and Laboratory Spray Dryer Bulletin 34. **Circle 134.**

Dryers, spray (p. 118). Consulting services available at Nichols Engineering & Research on spray-drying installations. **Circle 67.**

Ejectors, vacuum (p. 160). Bulletin from Jet-Vac gives complete technical data. **Circle 107.**

Equipment, processing, graphite (p. 29). New 32-page Report from Falls Industries gives cost estimation data on graphite exchangers, coolers, absorbers, pumps, valves, rupture discs, pipe & fittings. **Circle 68.**

Evaporators (p. 116). Detailed technical info in Bulletin PP 509-1 from Goslin-Birmingham. **Circle 73.**

ct guide to advertised products and services

CORRESPONDING NUMBERS ON DATA SERVICE CARD

Filter Materials (p. 134). Filter paper and cloth in variety of materials. Data from Filpaco Industries. **Circle 123-2.**

Filter Papers (p. 90). New Bulletin on "How to use Perforated Plates for Supporting Filter Paper." Eaton-Dikeman. **Circle 57.**

Filter Presses (p. 159). Catalog from D.R. Sperry includes data on auxiliaries such as closing devices and plate shifters. **Circle 10.**

Flowmeters (p. 133). Bulletin from Matheson features laboratory types. **Circle 72-4.**

Fused Quartz Ware (p. 167). Complete Catalog from Thermal American Fused Quartz gives details of "Vitreosil" line of laboratory and industrial ware. **Circle 3.**

Gas Generators (p. 142). Technical data from Gas Atmospheres, Inc., on complete line of packaged generators for inert, CO_2, nitrogen, hydrogen, reducing, and annealing gases. **Circle 125.**

Gaskets, ring, seamless (p. 175). In soft iron, copper, aluminum, Inconel, Monel, nickel, in range of sizes. Southern California Oil Tool Co. **Circle 70.**

Gauges (p. 156). Ranges from 15 to 20,000 lb./sq. in. Bulletin from Kunkle Valve. **Circle 35.**

Heat Exchangers, panel-coil (p. 22). Data Sheet 15-60 Series and Price Bulletin 259 from Dean Products. **Circle 59.**

Heat Exchangers, standardized (p. 153). Bulletin 820 from Manning & Lewis describes complete line. **Circle 7.**

Heat Transfer Equipment (p. 93). Bulletin HE-8 from Henry Vogt Machine Co. describes standard and custom-built heat transfer equipment. **Circle 11.**

Heaters, bayonet, tantalum (p. 27). Data from Fansteel Metallurgical. **Circle 79.**

Icing Systems (p. 140). Details from Flakice Corp. **Circle 69.**

Idlers, conveyor, pre-lubricated (p. 144). In 20, 35, and 45° equal and unequal length rolls with various roll diameters and tubing wall thicknesses. Info from Transall. **Circle 113.**

Indicator, for rotameters (p. 163). Bulletin 170 from Brooks Rotameter gives full technical details. **Circle 14.**

Indicator, shaft motion (p. 156). Protects machinery by indicating stoppages. Bulletin RG-21 from Bin-Dicator. **Circle 18.**

Jet-Venturi Equipment (p. 18). Technical info from Croll-Reynolds on many types of jet equipment—compressors, condensers, heaters, pumps, mixers, reactors, absorbers, scrubbers, special jet-Venturi units. **Circle 85.**

Joints, ball, flexible (p. 24). All sizes ½ to 16 in. Bulletin 215 from Barco Mfg. **Circle 2-3.**

Joints, expansion (p. 145). Technical data from Badger Mfg. **Circle 44.**

Joints, rotary (p. 24). Bulletin 310 from Barco Mfg. gives details of Type C rotary joints for steam, water, hot oil, air, gas, chemicals. **Circle 2-1.**

Joints, swivel, self-aligning (p. 24). For pressures to 850 lb./sq. in., temperatures from 750 to 1,000°F. Bulletin 265 from Barco Mfg. **Circle 2-2.**

Linings, tank, Hypalon (p. 129). Info from Du Pont on "Du Pont Elastomers in Industry." Also free subscription to "Elastomers Notebook." Du Pont. **Circle 149.**

continued on page 104

MATERIALS *from page 101*

Panthenol (p. 119-120). Data from U. S. Industrial Chemicals on use in toilet preparations. **Circle 138-3.**

Perfluoropropane (p. 133). Bulletin from Matheson describes potential as gaseous dielectric. **Circle 72-2.**

Polyethylene, finely-divided (p 119-120). Resin in powder form expected to expand use of polyethylene in textiles, paper, metals, chemical specialty fields. Data from U. S. Industrial Chemicals. **Circle 138-1.**

Sodium (p. 119-120). Info from U. S. Industrial Chemicals on use as coolant in small nuclear reactors designed for use in satellites. **Circle 138-4.**

Sodium Peroxide (p. 119-120). Data Sheet from U. S. Industrial Chemicals gives specs, typical analysis, properties, shipping data, uses. **Circle 138-2.**

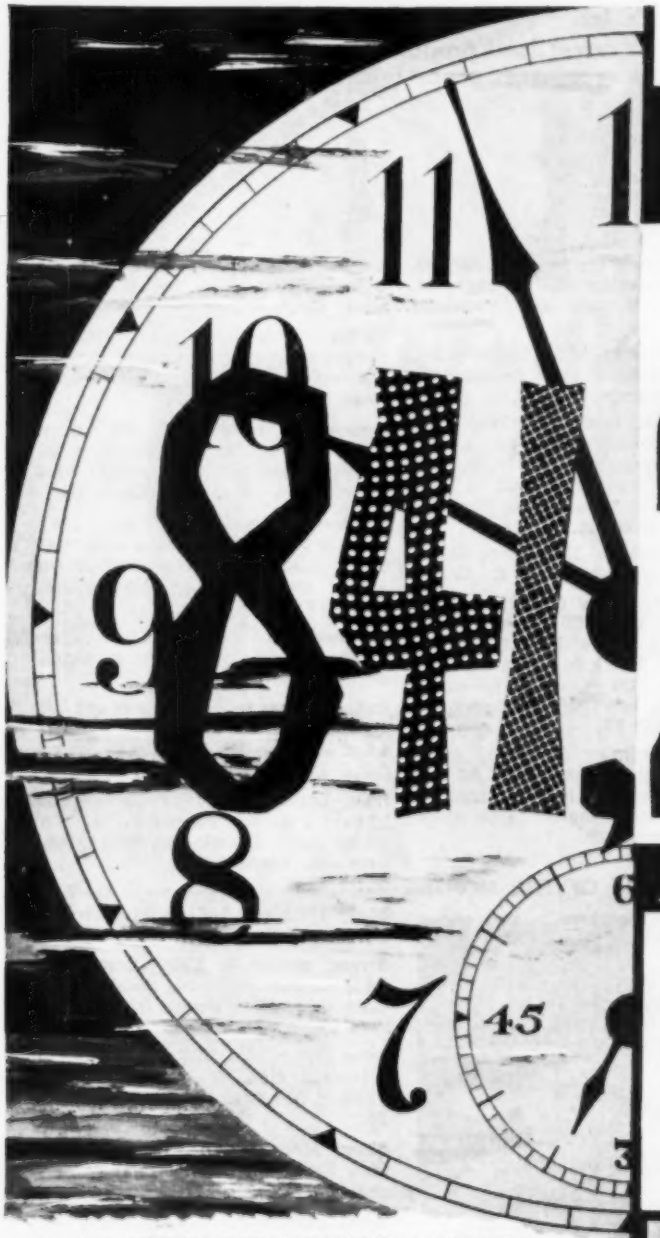
Steel, stainless (p. 125). Inventory Information from G. O. Carlson on all types of stainless steel plates and heads. **Circle 29.**

Surfactants, nonionic (p. 131). Technical data from Union Carbide Chemicals on its "Tergitol" line of nonionic surfactants. **Circle 97.**

SERVICES *from page 101*

Lubrication Research (p. 137). Contributions to the theory of lubrication from General Motors Research laboratories. **Circle 20.**

This card not valid after August, 1960.



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84,248 HOURS

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FOR EVERY PURPOSE.

PROVED IN USE FOR SUPERIOR QUALITY, DEPENDABILITY AND SAFETY . . .

Whether you count the hours, the days, or the years, world-wide industry has counted on NORWALK as the reliable source of compressors that fulfill every specification: from single stage to six stages; from 125 to 42,000 PSI pressure: for a full range of gases: Acetylene, Air, Argon, Specific Hydro Carbons, CO and CO_2, Ethane, Ethylene, HCL, Heliunr, Hydrogen, Nitrogen, Nitrous Oxide, Oxygen.

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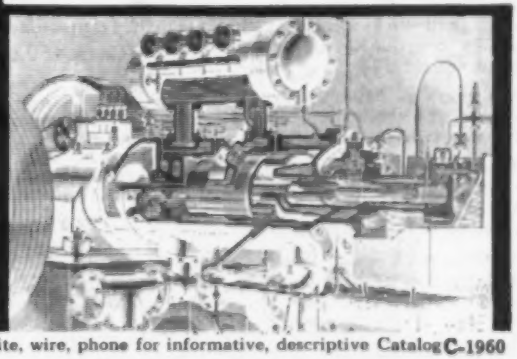

Write, wire, phone for informative, descriptive Catalog C-1960

NORWALK COMPANY, INC., SOUTH NORWALK, CONNECTICUT

COMPRESSOR SPECIALISTS TO WORLD-WIDE INDUSTRY SINCE 1864

For more information, turn to Data Service card, circle No. 61

CEP'S DATA SERVICE—Subject guide to advertised products and services

CIRCLE CORRESPONDING NUMBERS ON DATA SERVICE CARD

EQUIPMENT *from page 102*

Mills, hammer (p. 151). Reduce to 20 mesh. Bulletin 084 from Sturtevant Mill. **Circle 8-4.**

Mills, impact (p. 96). High intensity mixing for thorough and constant dispersion of trace ingredients. Info from Entoleter, Div. of American Mfg. **Circle 55.**

Mixers (p. 92). Technical data from Gabb Special Products on the "Shear-Flow" mixer. **Circle 81.**

Mixers (p. 97). Handbook on Mulling, 12-pages, gives details on 9 Mix-Muller models, ¾ to 60 cu. ft. capacity. Simpson Mix-Muller Div., National Engineering. **Circle 65.**

Mixers (p. 158). Technical info from Rapids Machinery on the "Marion" mixer. **Circle 127.**

Mixers (p. OBC). Consulting services on all types of mixing problems available at Mixing Equipment Co. **Circle 37.**

Mixers, portable (p. 164). Specially designed for small batch processes. Bulletin 530-E from Eastern Industries, Mixer Div. **Circle 26.**

Nozzles, spray (p. 158). Complete Catalog 24 from Spraying Systems. **Circle 112.**

Nozzles, spray (p. 162). Capacities from ⅛ pint/min. to 4,000 gal./min. In bronze, cast iron, stainless. Catalog from Spray Engineering. **Circle 109.**

Nozzles, spray (p. 167). Catalog 1 from Monarch Mfg. Works gives technical details on all types. **Circle 78.**

Packing, tower (p. 139). Comprehensive Booklet from Harshaw Chemical on application of "Tellerettes" to tower packing problems. **Circle 6.**

Preheaters, air (p. 117). Technical data from Air Preheater on the Ljungstrom continuous regeneration principle. **Circle 124.**

Processor (p. 140). Specially designed for heat-sensitive materials. Info from Kontro. **Circle 98.**

Pulverizer (p. 141). Catalog 87 from Combustion Engineering, Raymond Div., gives details of the IMP Mill, multi-purpose pulverizer. **Circle 66.**

Pulverizers (p. 160). American Pulverizer specializes in equipment for reducing or salvaging materials. Technical info. **Circle 28.**

Pumps, controlled-volume (p. IBC). Bulletin 553-1 from Milton Roy is general introduction to controlled-volume pumping. **Circle 12.**

Pumps, metering (p. 26). Catalog 59 from Lapp Insulator has 28 pages of metering pump data and methods. **Circle 36.**

Pumps, nuclear (p. 152). Specially designed for abusive applications. Info from Nagle Pumps. **Circle 133.**

Pumps, plastic, sealless (p. 146). For corrosives, abrasive slurries, gases. Discharge pressures to 60 lb./sq. in., temperatures from minus 60 to plus 400°F. Catalog from Vanton Pump & Equipment. **Circle 56.**

Pumps, process (p. 13). All technical details from Ingersoll-Rand. **Circle 64.**

Pumps, rotary screw (p. 88). Capacities from 1 to 2,000 gal./min., viscosities from 32 to 1,000,000 SSU, discharge to 1,000 lb./sq. in. for viscous liquids, 200 lb./sq. in. for water and light oils. Info from Sier-Bath Gear & Pump. **Circle 99.**

Pumps, self-priming (p. 166). Standard operating pressures 3 to 50 lb./sq. in. Catalog 58 has construction details, capacity charts. Ertel Engineering. **Circle 128.**

DEVELOPMENT OF THE MONTH

"THREE-IN-ONE" COMPUTER (Circle 602 on Data Post Card)

The new solid state IBM 7080 data processing system is reported to be the most powerful computer designed specifically for developing business information. The new machine has three modes of operation and can easily accept and process programs from the IBM 705 I, II and 705 III systems in addition to programs designed for the 7080.

The new system can make 303,000 logical decisions, read or write 312,500 characters of information, add or subtract 78,000 six-digit numbers, or multiply 7100 six-digit numbers in the time span of one second.

The IBM 7080 is said to be able to produce management reports, process payrolls, inventory control, and perform various accounting jobs.

For more information from International Business Machines Corp., Circle 602 on Data Post Card.

Pumps, small (p. 127). Info from Eco Engineering on rotary, centrifugal, gear types. **Circle 43.**

Pumps, vertical (p. 130). No submerged bearing. For pumping abrasive and corrosive slurries. Info from Lawrence Pumps. **Circle 108.**

Pyrometers, surface (p. 30). Scale range to 2,000°F, thermocouples for every application. Bulletin 4257 from Alnor on the "Pyrocon." **Circle 15.**

Reactors, glassed-steel (p. 107). Pfaudler Permutit introduces new "RA" Series Glassteel Reactors with many design improvements. Bulletin 988. **Circle 131.**

Rectifiers (p. 144). Sel-Rex offers Guide to Industrial Rectifier Equipment. **Circle 39.**

Reflux Splitter (p. 157). Pyrex and Teflon construction for corrosion resistance. Bulletin RS-2 from Chem Flow Corp. **Circle 30.**

Rolls, crushing (p. 151). Reduce soft to hard 2 in. and smaller materials to 12-20 mesh. Bulletin 065 from Sturtevant Mill. **Circle 8-3.**

Separators, entrainment (p. 4). Case Study 1003 and Bulletin 21 from Otto H. York. **Circle 130.**

Sieves, testing (p. 128). Exact openings, no crevices, strong durable cloth, cloth renewable. Details from Newark Wire Cloth. **Circle 13.**

Sifter, rotary (p. 5). Single or multiple separations as fine as 325 mesh. Bulletin 503 from B.F. Gump. **Circle 75.**

Sizing Machines (p. 148). Booklets from Simon-Carter on sizers, graders, separators. **Circle 74.**

Stills, molecular (p. 135). New Brochure from Arthur F. Smith on "Molecular Distillation with the Rota-Film Still." **Circle 4.**

Stirring Bars, magnetic (p. 164). In Teflon, Kel-F, Tygon, and polyethylene. Data from Laboratory Plasticware Fabricators. **Circle 122.**

Storage Spheres, cryogenic (p. 149). Info from Graver Tank & Mfg. **Circle 147.**

Surge Absorbers (p. 32). Wide range of sizes and pressure ratings. Data from Hydril Co. **Circle 16.**

Tanks, rubber-lined (p. 134). Complete technical data from Gates Rubber Co. **Circle 80.**

continued on page 106

NOW...

DeZurik Valves with VITON-COVERED PLUGS for LONG LIFE ON CORROSIVE LIQUIDS, SLURRIES, GASES!

Successful applications of DeZurik Valves with VITON covered plugs include Sodium Sulphide, Polyester Resin, Naphtha, Hot Tallow, Fish Oil, Maleic Acid, Phthalic Acid, Sulfurous Acid, Fuel Oil, Tar, Raw Coke Oven Gas, Sodium Hypochlorite, Coal Tar, Phosphoric Acid, Hexane, Tetraethyl Lead, Sulphuric Acid, Epoxy Resin, Chlorine, Ferrous Sulfate, Styrene, Gasoline, Nickel Carbonyl Gas, Hydrofluoric Acid, Formaldehyde, Steam, Perchlorothylene, Trisodium Phosphate.

DeZurik Valves are available in Semi-Steel, Bronze, Acid Resisting Bronze, Ni-Resist, Aluminum, Carbon Steel, Stainless Steel, Alloy 20, Nickel, Monel, Hastelloy B, Hastelloy C, and other metals.

This DeZurik Eccentric Valve, with Viton-covered plug, will CLOSE TIGHT and LAST LONGER on high temperature corrosives.

The physical properties of VITON are particularly desirable when combined with DeZurik Eccentric Valves. Its *resiliency* guarantees tight shut off, even on slurries! Its *temperature resistance* greatly extends the range of installations on which DeZurik Valves can be advantageously employed. And its *resistance to chemical attack* is shown in the partial list on the left.

These properties make VITON one of the fastest-growing members of the family of DeZurik plug-covering materials.

DeZURIK CORPORATION
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For more information, turn to Reader Service card, circle No. 19

CEP'S DATA SERVICE—Subject guide to advertised products and services

CIRCLE CORRESPONDING NUMBERS ON DATA SERVICE CARD

EQUIPMENT *from page 104*

Tanks, stainless (p. 134). For storage and mixing. Vertical, horizontal, regular styles. Info from Filpaco Industries. **Circle 123-1.**

Tanks, stainless steel (p. 12). Data Sheet Bulletin 1159 "SC" Series from Doyle & Roth Mfg. gives details of standardized models. **Circle 132.**

Temperature Control Instruments (p. 136). Off-on, proportioning, high-level, stepless, program. Bulletin COM from West Instrument. **Circle 31.**

Thermocouple Extension Wire (p. 152). Bulletin 1200-3 from Claud S. Gordon gives specifications, technical data. **Circle 76.**

Tubing, plastic (p. 85). Bulletin T-100 from U. S. Stoneware gives technical data on "Tygon" corrosion-resistant plastic piping. 65 sizes to 4 in. O.D. **Circle 54.**

Tubing, Teflon (p. 161). Toughness and flexibility in temperature range from minus 90 to plus 250°C. Data from L. Frank Markel & Sons. **Circle 9.**

Tubing Bundles (p. 163). Polyethylene tubes enclosed in PVC sheath. Bulletin PPI-59. Pyramid Plastics. **Circle 38.**

Vacuum Producers (p. 25). Bulletin 5H-HS from Schutte & Koerting gives complete technical details of packaged "Hydro-Steam" units. **Circle 83.**

Valves, control (p. 150). Complete details from George W. Dahl on compact in-line on-off control valves. **Circle 58.**

Valves, corrosion-resistant (p. 105). Data from DeZurik on valves with Viton-covered plugs for corrosive liquids, slurries, gases. **Circle 19.**

Valves, diaphragm, motor (p. 162). Technical data from Fisher Governor. **Circle 24.**

Valves, "Flo-Ball." (p. 19-20). Details from Hydromatics on new design claimed to have better flow than gate valves, better sealing than globe valves, better reliability than plug valves. **Circle 137.**

Valves, split-body (p. 36). Interchangeable construction permits 432 valve combinations from single split-body. Catalog 132 from Kieley & Mueller. **Circle 41.**

Vessels, cryogenic (p. 89). For low-temperature storage of oxygen, methane, ethylene, nitrogen, hydrogen. Info from Chicago Bridge & Iron. **Circle 42.**

Viscometer (p. 10). For end point determination and continuous in-process viscosity recording. Application Data Sheet from Brookfield Engineering Laboratories. **Circle 23.**

Water Treatment Systems (p. 95). Technical data from Eimco on the Eimco-Process system for recovery of waste process water. **Circle 100.**

SUBJECT GUIDE to free technical literature

CIRCLE CORRESPONDING NUMBERS ON DATA SERVICE CARD

EQUIPMENT

301 Chains and Sprockets. New 44-page Book with over 2000 types and sizes of roller chains and sprockets from Link-Belt Co.

302 Chromatographs, gas. Bulletin from Beckman describes industrial gas chromatographs used for process stream analysis.

303 Classifiers, spiral. New 28-page Catalog presents principles, design details, capacities, applications of spiral classifiers from Mine and Smelter Supply Co.

304 Collector, dust. Bulletin describes equipment for collecting and conveying fine particles. Data from Mikro-Products.

305 Compressors, air. New 16-page Bulletin entitled "Economical Air for Industrial Needs" includes details of new DMR compressors from Cooper-Bessemer.

306 Computer. Brochure describes features of Control Data Corporation's all-transistorized digital computer 1604.

continued on page 108

MATERIALS

337 Alloy, high temperature. Booklet from Westinghouse gives technical data on W-545 vacuum melted, high temperature alloy.

338 Aluminum. A survey of aluminum welding, brazing, and soldering is in Manual from All-State Welding Alloys Co.

339 Aluminum Alloys. A 24-page Booklet from Olin Mathieson Chemical Corp. is a selection guide and handy reference for aluminum alloy users.

340 Bearings, aluminum. Ninety-pages of Technical information from Aluminum Company of America covers engineering and test data of aluminum bearings.

341 Benzotrifluoride, isomers. Details for four fluorinated chemical compounds reviewed in Bulletin from Hooker Chemical Corp.

342 Carbon Dioxide. New 24-page Booklet has applications, properties, manufacture, and distribution of solid, liquid, gaseous CO_2. Pure Carbonic Co.

continued on page 108

SERVICES

355 Calorimetry, manual. New 56-page Technical Manual on oxygen bomb calorimetry is available from Parr Instrument Co.

356 Chart, hardness conversion. Chart showing relation between hardness by various testing systems and tensile strength of carbon and alloy steels. Babcock & Wilcox.

357 Facilities, research and development. Brochure describes services, facilities, engineering projects of Microtech Research Co.

358 Facilities and Services. Bulletin from Vulcan Mfg. describes manufacturing facilities and equipment design services.

359 Ion exchange. Complete description of the ion exchange process used in water conditioning is available from Pfaudler-Permutit, Inc.

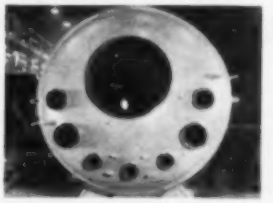
360 Maintenance, glassed-steel reactor. Twelve-page Manual from Pfaudler Co. gives installation, operation, maintenance data for glass-lined reactors.

continued on page 108

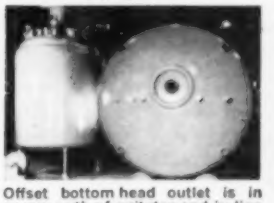
FLUIDICS* AT WORK

Different silhouette and light-blue exterior tell you the Pfaudler "RA" Series Glasteel Reactor is new. Unit shown has BH drive.

TW drive, one of two new drives, provides increased stability for agitator shaft. Runs very quietly.



"Mirror image" provides like-size nozzles on each half of top head. Facilitates piping.



Offset bottom head outlet is in sweep path of agitator and in line with top head manhole.

NEW from top to bottom . . . Pfaudler "RA" Series Reactors

The old "Pfaudlers" (R Series) that you're so familiar with are passing from the scene.

In their place, we now offer the all-new "RA" Series Glasteel Reactors with many significant design improvements.

Two New Drives. Starting at the top, you'll find the TW drive on the 300 through 1000 gallon reactors for power requirements to 15 H.P. The BH drive takes over on the 1500 gallon and larger sizes for power requirements to 60 H.P.

Both drive designs are compact, easily installed and maintained. Very quiet, too—a difference that's appreciated when operating a full line of reactors.

Mirror-Image Top Head. Next note the equal number of nozzles on each half of the top head, placed symmetrically for ample freedom in piping. For example, you can feed two reactors from a single tee—one to the left, one to the right.

And, since there are no cumbersome drive supports, you have convenient access to manhole, observation window, nozzles, drives, baffles, dip pipe and mechanical seal.

Offset Drain. Off the bottom head you get fast drainage, since the outlet has been offset from center to a position in the direct sweep path of the agitator. Also, the outlet is in line with the top head manhole for convenient inspection.

Corrosion Resistance. Of course, inside there's Glasteel 59. Excellent resistance to all acids (except HF) to 350° F. and on to 450° F., depending on concentration. Mild alkalies at moderate temperatures are also permissible. Thermal shock resistance is up 30% over the "R" Series. At a vessel temperature of 250° F., your recommended safe temperature differential is now 260° F. Abrasion resistance has also been increased by 20%. Glasteel 59 is smooth—resists build-up of sticky products. As a result, you have high heat-transfer rates, increased product yield, fewer shutdowns for cleaning, and much longer service life.

Stock Delivery. Standard "RA" Series Reactors range in size from 300 to 4000 gallons with the 500, 750, 1000 and 2000 gallon vessels stocked for two-week delivery from receipt of your order.

Write for specifications. New Bulletin No. 988 is now available. For your copy, write to our Pfaudler Division, Dept. CEP-50, Rochester 3, New York.

Yield up, costs down for Johnson's Wax with Titan centrifuge

When you take the wax from the carnauba palm tree leaf, the wax becomes contaminated with residual leafy particles.

Since S. C. Johnson & Son, Inc., Racine, Wisconsin, uses large quantities of carnauba wax in their many products, the cost of raw materials and clarifying are significant.

Before turning to centrifuging, some refined carnauba was purchased, and considerable crude was clarified using plate and frame filters. Costs were high. Yields were low.

Then the Pfaudler Titan Superjector was installed. Yields of clarified crude increased from 90% to 97%. Consider that the value of refined carnauba is 80 cents a pound, and these savings take on real proportions. Also, the quality of the clarified wax is excellent, so that it's no longer necessary to purchase premium-priced "refined" grade.

Carnauba wax melts at 180° F., therefore, the Titan centrifuge at S. C. Johnson was specially equipped to maintain a bowl temperature of approximately 240° F.

Other Uses. The unique "Select-eject control" in a Pfaudler centrifuge provides broad-range product handling. With continuous feed and solids-only discharge, you get maximum dewatering and concentration of slimy solids. With instantaneous discharge of full bowl contents, coarse, compacting-type granular solids are effectively handled.

See for Yourself. Schedule a test of your product in Pfaudler's Test Center or in your own plant under production-scale conditions with a Pfaudler field evaluation unit. For details, write for Bulletin No. 946.

FLUIDICS wherever you are: Pfaudler Permutit is a world-wide company with plants in Germany, Great Britain, Canada, Mexico, Japan and four in the United States.

*FLUIDICS is the Pfaudler Permutit program that integrates knowledge, equipment and experience in solving problems involving fluids.

PFAUDLER PERMUTIT INC.

Specialists in FLUIDICS . . . the science of fluid processes

For more information, turn to Data Service card, circle No. 131

CEP'S DATA SERVICE— Subject guide to free technical literature

CIRCLE CORRESPONDING NUMBERS ON DATA SERVICE CARD

EQUIPMENT *from page 106*

307 Computer, transistorized. Information for general purpose digital computer RPC-4000 for business and engineering data from Royal McBee Corp.

308 Conditioner, water. Information for equipment and soluble phosphate material for treating water is available from Stiles-Karlsonite Corp.

309 Cryogenic Systems. New Brochure from Air Products Inc. describes miniature refrigeration systems for cooling electronic devices from 3.5 to 200°K.

310 Data Processing System. Brochure describes the Burroughs 220 electronic data processing system.

311 Diaphragm Seals. A new Catalog from Brooks Rotameter Co. gives full description, specifications, prices for corrosion and clogging protective seals.

312 Distillation, ballast tray. Technical Bulletin gives performance curves and operating data for V-1 fractionating device from Fritz W. Glitsch & Sons.

314 Dryers, heat-less. Bulletin DD-180 gives advantages, operation, capacity of gas dryers from Trinity Equipment Corp.

315 Dumpers. Details of equipment for lifting and dumping free flowing materials from Conveyors and Dumpers, Inc.

316 Equipment. Catalog presents capacities of air and liquid handling equipment, heat exchangers, boilers, etc. from American-Standard.

317 Equipment, plant. Booklet covers pumps, compressors, condensers, vacuum equipment, and air hoists available from Ingersoll-Rand.

318 Equipment, plastic. Catalog lists specialized Teflon coating for metal parts by fabricator—Laboratory Plasticware Fabricators.

319 Fans, low-speed, high-volume. Revised Bulletin from Hartzell Propeller Fan Co. describes complete line of industrial fans.

320 Filters. New 16-page Booklet describes filtration products for industrial processes. Purolator Products, Inc.

321 Fuel Cells. Booklet from General Electric discusses basic facts, features, types of fuel cells under investigation.

322 Gas Engine, turbocharged. A 26-page Bulletin completely describes compact, high horsepower driver for compressors, generators, pumps. Clark Bros. Co.

323 Heat Exchangers. Technical Data Sheets from Dean Products, Inc. describes heating and cooling applications of Dean Panelcoils.

324 Heat Exchangers. Booklet containing applications, design specifications for heat exchangers from Reynolds Metals Co.

325 Heat Exchanger, graphite. Twenty-page Engineering Manual containing design data for impervious graphite heat exchangers from Carbone Corp.

326 Instruments, level. Bulletin of continuous level indicator/controllers for liquids or granular solids from Instruments, Inc.

327 Instrument, volume of solids. Description and operating details of invention for measuring true volume, density, porosity of solids. Houston Instrument Corp.

328 Pipe, armored. Bulletin describing properties of fiber glass reinforced plastic pipe for chemical corrosion control available from Haveg Industries.

329 Pipe, fittings. Details of Plainlock method of connecting plain or beveled end pipe from Victaulic Company of America.

330 Pump, metering. Design features, materials of construction, selection data available in Brochure from American Meter Co.

331 Switch, magnetic. Detailed information available from Space Components Inc. for new, environment proof, magnetically activated switch.

332 Tanks, wood. A 28-page reference and data Handbook contains information concerning applications of wood tanks in the chemical industry. Wendnagel and Co.

333 Thermocouple Assemblies. New 40-page Catalog and price list contains information for industrial thermocouple applications. Minneapolis-Honeywell Regulator Co.

336 Valve, solenoid. Selection Manual for solenoid valves from Valcor Eng. Corp. lists corrosive applications and materials.

MATERIALS *from page 106*

343 Chemicals. Forty-page 1960 Catalog lists names, formulas, properties of 200 research chemicals from Dow Chemical Co.

344 Chemicals, rubber industry. Brochure describes physical, chemical properties of materials for rubber and polyurethane industries. Eastman Chemical Products.

345 Coatings. A 13-page Booklet with specifications, properties, uses for complete line of coal-tar protective coatings from Allied Chemical Corp.

346 Insulations. Catalog covering complete line of industrial insulations for sub-zero to 1900°F service from Baldwin-Ehret-Hill, Inc.

347 Insulation, inorganic. Catalog describing rigid inorganic insulaton for electronic and missile industries from Haveg Industries, Inc.

348 Lubricant. Bulletin 126B presents properties of Molykote G lubricant. Small sample tube also available from Alpha-Molykote Corp.

349 Molybdenum. Booklet describes molybdenum products, their forms and applications. Data from Climax Molybdenum Co.

350 Plastics. New 64-page Catalog contains information on plastics available in sheet, rod, tube, films. Commercial Plastics & Supply Corp.

351 Plastics. New 36-page Catalog from Raybestos-Manhattan, Inc. describes properties and shapes of complete line of plastic products.

352 Polyethylene Glycols. New 40-page Booklet from Union Carbide Chemicals presents technical information and applications for Carbowax polyethylene glycols.

353 Silicones. Engineering Guide gives summary of forms, properties, applications of silicones from Dow Corning Corp.

354 Stainless Steel, chart. Revised Data Chart from Peter A. Frasse & Co. provides analyses of 58 different stainless steels with SAE, AMS, and AISI designations.

SERVICES *from page 106*

361 Psychrometric Chart. Humidity Chart from J. O. Ross Engineering contains enthalpy table of moist air.

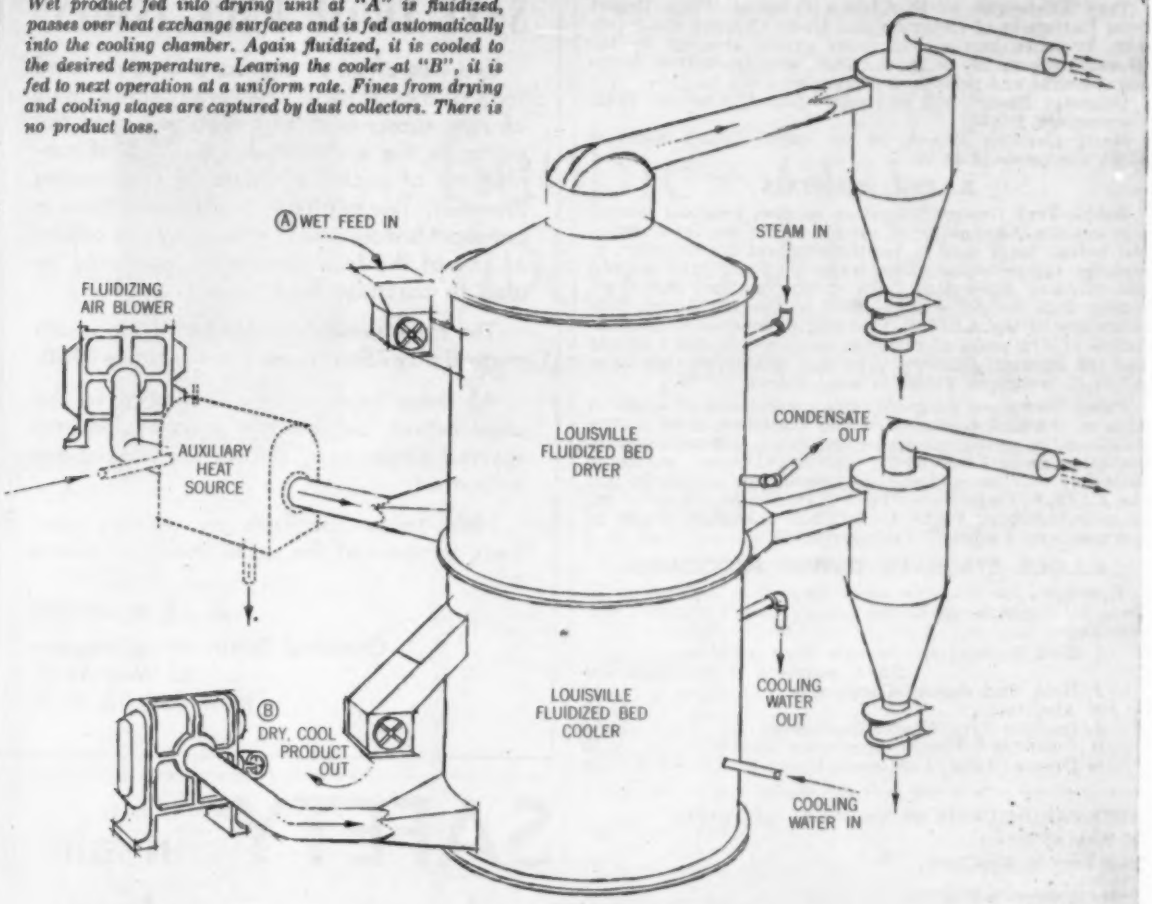
362 Radioisotope Wall Chart. Important information on dosimetry, decay, gamma ray absorption and spectra, etc. are available on wall chart from Baird-Atomic, Inc.

363 Slide Rule. Information concerning the availability of a circular slide rule and concise conversion tables marketed by Sama & Etani.

A.I.Ch.E. Membership

Brochure—"Know Your Institute"—tells objective aim and benefits to chemical engineers who join this nation-wide organization, includes membership blank. Circle number 600 on Data Post Card.

Wet product fed into drying unit at "A" is fluidized, passes over heat exchange surfaces and is fed automatically into the cooling chamber. Again fluidized, it is cooled to the desired temperature. Leaving the cooler at "B", it is fed to next operation at a uniform rate. Fines from drying and cooling stages are captured by dust collectors. There is no product loss.



Major break-through in drying and cooling techniques announced by

GENERAL AMERICAN

A new system for drying and cooling has been perfected by General American Transportation Corporation through their development of Louisville Fluidized Bed* equipment. Two Louisville units, one functioning as a dryer and one as a cooler are coupled vertically to provide a continuous automatic operation.

The system is particularly useful for crystalline chemicals, resins, polyvinyl acetate beads, polyethylene pellets, sugar and similar products having the proper particle size distribution.

Louisville Fluidized Bed equipment offers these advantages:

1. Accurate, instantaneous temperature control
2. High heat transfer that permits compact design
3. Low maintenance costs (no moving parts)
4. Less cleaning time and labor
5. Less floor space (equipment is vertical)
6. No hot spots (product is fully protected)

Because of their simplicity, Louisville Fluidized Bed dryers and coolers adapt readily to complete automation.

For full details about this revolutionary development in drying techniques, write Dept. G

Process Equipment Division
GENERAL AMERICAN TRANSPORTATION CORPORATION
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Chicago 3, Illinois
Offices in principal cities

*Patents Pending

For more information, turn to Data Service card, circle No. 33

5 DAYS FREE EXAMINATION

Tray Efficiencies in Distillation Columns—Final Report from University of Delaware and North Carolina State College. Research carried out under grants awarded by the Research Committee of the A.I.Ch.E. with funds from forty-one chemical and petroleum companies:

Delaware Report, 120 pp., paper bound. Members $5.00, nonmembers $10.00.

North Carolina Report, 28 pp., paper bound. Members $2.00, nonmembers $4.00.

A.I.Ch.E. MANUALS

Bubble-Tray Design Manual—a concise, practical manual that enables the engineer to predict efficiencies for commercial bubble trays used in multi-component fractionation. It includes sample calculations made on plant-scale columns and contains calculation form sheets for the use of the reader. This manual was produced by the Distillation Subcommittee of the A.I.Ch.E. Research Committee as a culmination of five years of research sponsored by the Institute and the chemical industry. 6 by 9 in., hard cover, $5.00 to A.I.Ch.E. members, $10.00 to nonmembers.

Pump Manual—a comprehensive presentation of available data on chemical pumps, including classification of pumps, relationships among categories and types, nomenclature, installation check lists, inquiry and record forms, guides to materials of construction, ASA mechanical standards, and the A.I.Ch.E. Performance Testing Procedure. 8½ by 11 in., loose-leaf format, $10.00 to A.I.Ch.E. members, $20.00 to nonmembers. Published February, 1960.

A.I.Ch.E. STANDARD TESTING PROCEDURES

Directions for directing and interpreting tests of equipment for comparison with the manufacturer's predicted performance.

1. Heat Exchangers—Sensible Shell and Tube, ... $.25 to members $.50 nonmembers
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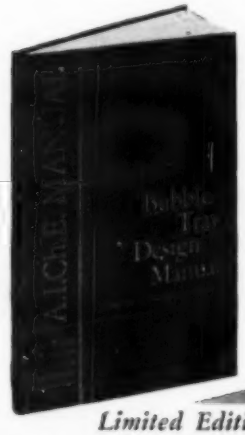

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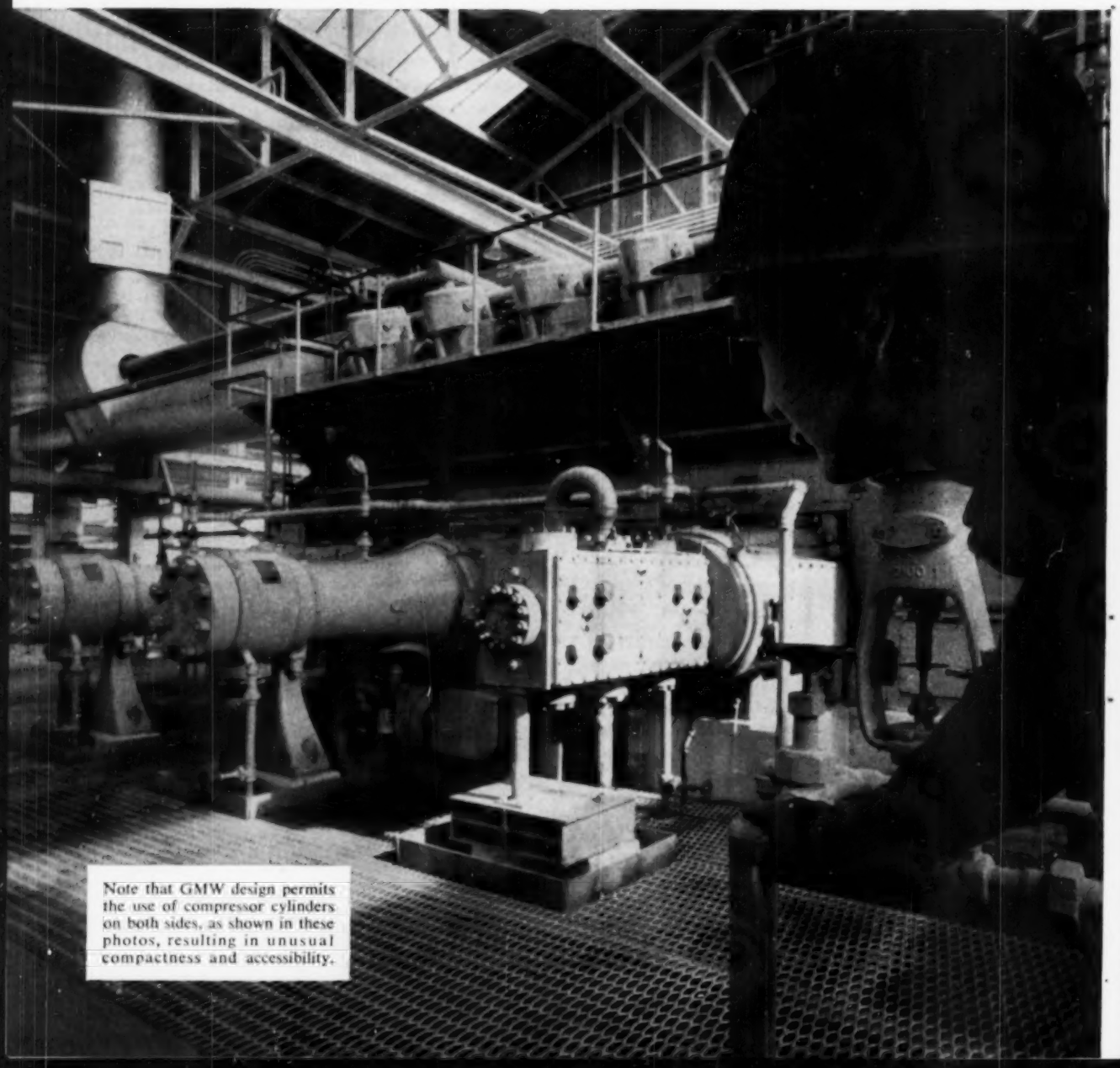
Report from American Cyanamid, Fortier Plant...

How Cooper-Bessemer gas engine boost synthesis gas for ammonia



Note that GMW design permits the use of compressor cylinders on both sides, as shown in these photos, resulting in unusual compactness and accessibility.

compressors to 5000 psi

These photos show both sides of one of the two Cooper-Bessemer 2500 hp GMW gas engine compressors at the Fortier Plant of American Cyanamid Company, Avondale, Louisiana. In the production of anhydrous ammonia, these 4-stage units compress 6000 cfm of synthesis gas from 60 psi to a discharge of 5000 psi. The left-hand view shows the high pressure cylinders; that on the right shows the low pressure side. The four stages of compression from 60 psi are (1) to 225 psi, (2) to 670 psi, (3) to 1500 psi, (4) to 5000 psi.

The two units have been operating since 1954, 24 hours a day, 340 days a year.

The anhydrous ammonia produced at the Fortier Plant is used by American Cyanamid in the manufacture of Acrylonitrile and is sold to fertilizer plants and other chemical companies.

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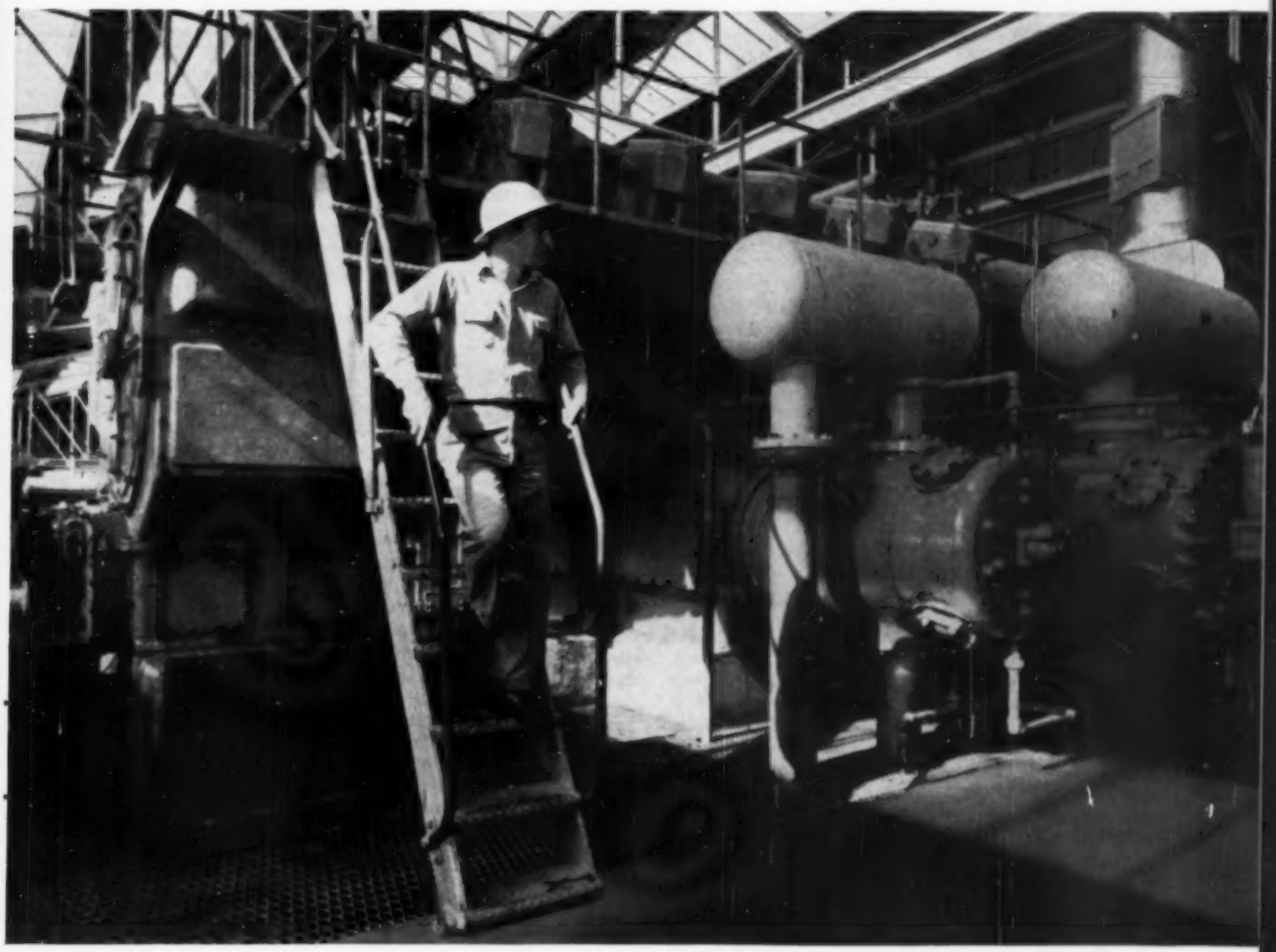

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chemical feature

Organometallics are big business

Multiplicity of relatively small uses adds up to multi-million dollar sales for now booming organometallic compounds. Key—versatility.

FROM A STANDING START as laboratory curiosities, no more than fifteen or twenty years ago, organometallics have mushroomed into a multi-million-dollar-a-year affair. While a good percentage of today's sales volume is concentrated in a few major fields, a growing part is spread over a surprising variety of uses, some of them quite unexpected only a short while ago.

Largest, most-publicized use is, of course, tetraethyl lead as an antiknock additive for motor fuels. Notable new development here is the recent unveiling of the tetramethyl compound, claimed to have superior volatility properties.

Next in order of volume come the silicones and silanes, which, as metalloids, should technically be considered as organometallics. Interesting work (still in the evaluation stage) is going on in use of the silanes as high-temperature fluids, perhaps also for low-temperature applications. Merck, Stauffer, Callery, are reported to be involved in these developments, as well as Metal & Thermit, which produces some of the silanes.

Organotins

Metal and Thermit is the world's largest producer of organotin compounds. Production is also increasing abroad, particularly in England, Switzerland, Japan, and Germany.

The exponential character of the growth rate for organotins is illustrated by the fact that, in 1956, about 150,000 pounds of tin metal were used in preparation of organotins, compared to 500 pounds only ten years previous. Present production figures have not been divulged, but estimates place U. S. production at something under 2 million pounds annually, world production at approximately double that figure. Price range is \$2.00 to \$4.00/lb., with the average running between \$2.25 and \$2.80.

Uses are multifarious.

Tetraphenyltin is an anti-corrosion additive in chlorinated diphenyls.

Salts of butyltin (the maleate and the dilaurate) were important as stabilizers in PVC formulations, but these have been replaced more recently by organotin sulfur derivatives.

Dibutyltin dilaurate has also found extensive use as an anthelmintic in the veterinary treatment of poultry.

Mono– and dibutyltin salts are silicone curing catalysts.

Patents have been issued (1943) covering use of organotins as antifouling additives in marine paints.

Several of the compounds are widely employed as fungicides and algaecides. In particular, tributyltin oxide is used for slime control in paper mills, while trialkyltins are used as wood preservatives, textile preservatives, for mildew-proofing, and as insecticides.

Some are used as catalysts for production of urethane foams. Relative catalytic activity of dibutyltin dilaurate, for example, is reported to be 37,000 compared to 11 for the conventionally used triethylamine in the reaction between phenyl isocyanate and methanol.

Reliable statistics on total U.S. production of organoaluminums are hard to come by—an educated guess might be in the neighborhood of one million pounds annually.

Big use today, sparked by the discoveries of Ziegler and Natta in "stereospecific" catalysis, is as catalysts for low-pressure polymerization of ethylene and propylene, and in preparation of straight-chain primary alcohols. Most used compounds are the trimethyl, triethyl, and triisobutyl aluminums, the last two being important in the polymerization reactions.

Production today is mostly for captive use by the large plastic producers. Union Carbide Chemicals, Ethyl, Dupont, Esso, are reported developing and producing organoaluminum catalysts, in addition to Stauffer and Hercules Powder which have combined forces to form Texas Alkyls, Inc. The new jointly-owned company will put up a plant at Houston, Texas, for large-scale commercial production of organoaluminums, hopes to be in production by some time in 1961.

These catalysts, in their simple form, do not always suffice for the olefin polymerization reaction. In some cases, for instance, it is necessary to add titanium or vanadium compounds to furnish the negative ion needed for the polymerization propagation step in the process.

Ethylene and propylene polymerization do not represent the end of the road—perhaps only the beginning. Just over the horizon may be use of this same type of catalyst for commercial polymerization of butadiene, chloroprene, formaldehyde, isoprene, other olefins.

Alcohols

Continental Oil's new "Alfol" process for straight-chain primary alcohols also stems from the work of Ziegler, also involves a triethylaluminum catalyst. Production at a new Conoco plant is slated for 1961.

The versatility of the organoaluminums has by no means been exhausted. A little way in the future are perhaps:

Gas-phase aluminum plating on both metals and non-metals;

Organoaluminums as pyrophoric fuels for ram-jet-powered missiles, and as high-altitutde jet-flame sustainers in turbojet engines.

Organoboranes

Hailed only two or three years ago

continued on page 116

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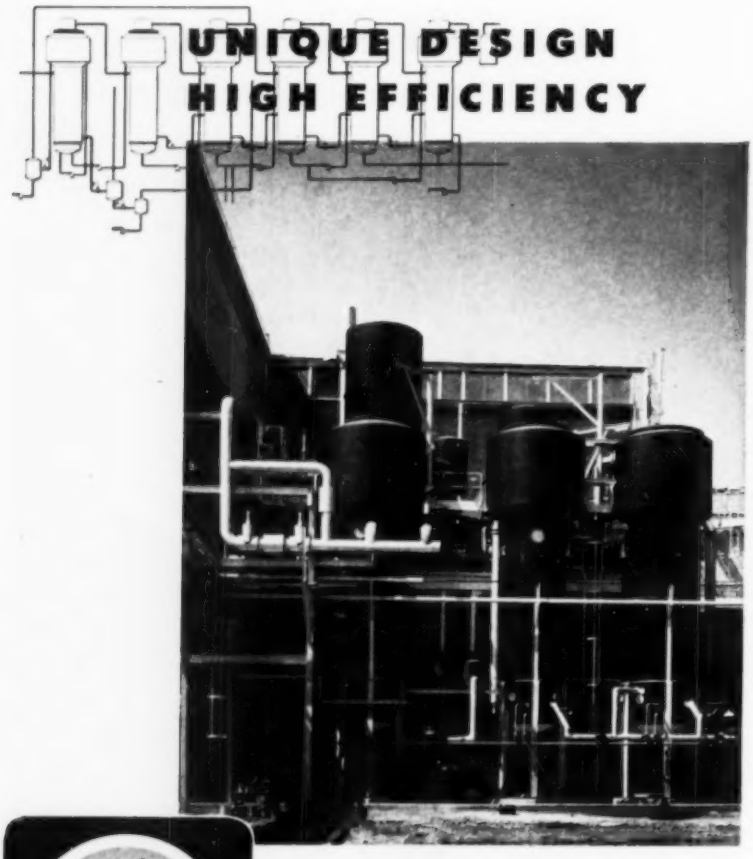

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This six body, sextuple effect evaporator system was installed in a U-shaped arrangement and was designed to concentrate 428,000 lbs. of black liquor from 14 per cent to 50 per cent solids content, when supplied with 56,000 lbs. per hour of 45 psi steam. The high efficiency of this system (5.52 lbs. of water per pound of steam) was made possible through a new and novel feed arrangement into the evaporators. The first effect evaporator is equipped with 2 inch diameter stainless steel tubes while the other five have welded seam carbon steel tubes.

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Organometallics

from page 114

as the answer to the high-energy fuel problem, organoboranes have received a severe setback with the shifting of military requirements and the resulting shutdown of Olin Mathiesons Niagara Falls plant and Callery's Muskogee, Okla., facilities.

The small fry

Production of phenylmercurials is estimated to command a market of over $1 million annually, chiefly for algaecides and fungicides.

Further down the sales ladder, come other smaller-volume organometallics such as the triphenyl antimony, bismuth, and phosphorus compounds, all turned out in pilot-plant quantities at Metal & Thermit for unspecified—perhaps classified—uses. Prices range from $3 to $20/lb.

On still lower rungs of the ladder, are found a great many other organometallics, such as the zinc and cadmium compounds, today only laboratory "curiosities," but which may well be dark horses or sleepers.

Organometallic polymers

Way out into the "blue-sky" region are the organometallic polymers, subject of a recent symposium at Armstrong Cork Co. in Lancaster, Pa. Object of the work, still in the research stage, is "creation or design of entirely new materials for extreme conditions of temperature, pressure, speed, corrosion, and radiation."

Tropical diseases

Little-known aspect of the organometallics, except perhaps in specialized medical circles, is their wide use in treatment of a large variety of tropical diseases—Oroya fever, Chinese leishmaniasis, etc., etc. U.S. research in this direction was accelerated during World War II, when American troops were deployed to the four corners of the earth, has tended to languish somewhat since the end of hostilities. Principal weapons in the organometallic medical arsenal are compounds of arsenic and antimony, both of which, interestingly, were used in the ancient world as pharmaceuticals.

Off-beat chemical engineering

According to Metal & Thermit's C.K. Banks, V.P. for R & D, processes for production of organometallics can present unexpected difficulties, not al-

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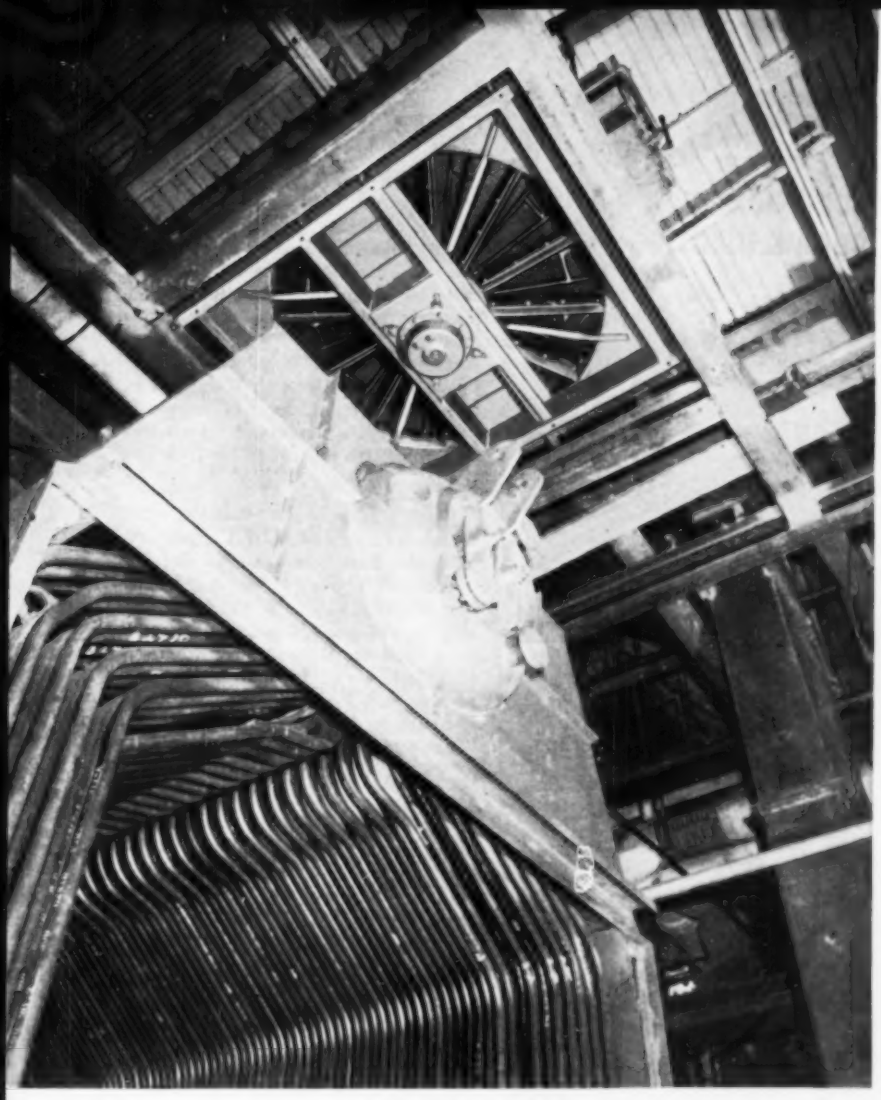
For more information, circle No. 124



The Ljungstrom Air Preheater at the B. F. Goodrich Company Shelton Plant is installed directly over the 65,000 lb/hr Wickes boiler. Flue gas leaving the boiler at 615°F passes through the circular rotor, which absorbs the heat and releases it into the incoming air. Preheated combustion air improves combustion, makes fuel burn cleanly. This Package Air Preheater was factory-assembled, and requird only 100 manhours to install.

At B. F. Goodrich Co.'s Shelton Plant

Air Preheater boosts combustion air temperature 345°F... gives 6% more thermal efficiency

"Only a Ljungstrom® Air Preheater, with its continuous regenerative principle, could meet our requirements", says A. G. Sandomirsky, Manager of Engineering at the B. F. Goodrich Company, Shelton, Conn., plant. "We produce foam rubber 24 hours a day, five and six days a week. With an Air Preheater we can meet process steam requirements more economically, and an Air Preheater helped us to justify the installation of high efficiency, high pressure equipment for by-product power generation."

Here's why the Shelton plant meets its requirements best with a Ljungstrom Air Preheater:

1. Ljungstrom is the most efficient heat exchanger you can buy. The Ljungstrom rotor revolves continuously through the flue gas and incoming air, thus absorbing heat and releasing it *from the same surface*. Since the heat doesn't have to pass through anything, each inch of rotor surface is as efficient as one foot of a tubular recuperator.

2. Ljungstrom is the most reliable heat exchanger you can buy. All heat exchange elements pass through the entire air and gas streams. The temperature of the elements in the coolest region – where fresh air enters – is actually an average of the gas and air temperatures, so it's consistently higher than the coolest point in a recuperative heat exchanger. Result: no cold spots, less chance of moisture formation.

3. Ljungstrom is easiest to maintain. You can inspect it – and clean it–while it's running. Heat exchange elements are divided into modular baskets that can be replaced individually without disturbing the other elements. You can even reverse the elements if the surface has thinned on one edge, effectively doubling the life of the heat exchange surface.

For more information on the Ljungstrom continuous regenerative principle, or on the Air Preheater that meets your requirements, phone MUrray Hill 2-8250 or write to The Air Preheater Corporation.

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Organometallics

from page 116

ways resolved by conventional, time-tested chemical engineering techniques. Reason lies mainly in the physical and chemical properties of the materials themselves. Distillation, for instance, says Banks, can be a major headache, due to the extremely high surface tensions involved. Most of the equipment at Metal & Thermit, in fact, was designed by the company's own engineers and built to custom specifications.

Russian work

Quality of published Russian work in the organometallic field, according to Banks, has shown an amazing improvement in the last ten years. The best Russian work, he says, particularly in the more theoretical aspects, is at least on a par with U.S. work, is prima facie evidence that the powers-that-be in the Soviet Union have deemed it prudent to allocate a considerable priority to the field.

Expansion of manufacturing facilities into ethylene dichloride, caustic soda and chlorine, is in the mill at C.S.R.C.-Dow Pty. Ltd., Dow associated Australian company. Ethylene dichloride will be supplied to B. F. Goodrich for producing polyvinyl chloride resins, while the caustic soda will go to Australian consumers. The Altona, Australia, firm also makes styrene monomer.

The addition of a chemical engineering program to the curriculum of two major New Jersey colleges is expected to help solve the long urgent shortage of engineers in the metropolitan area. Rutgers College of Engineering has added a degree program in chemical engineering to the undergraduate school, starting with the fall term. Stevens Institute of Technology as part of its expanding policy in the school of graduate studies, will offer a program leading to a doctor of science degree in chemical engineering.

Canada's second nuclear research center will be built on a site near Winnipeg, Manitoba. Some work on the Whiteshell Nuclear Research Establishment will start this summer, with construction on the major research center due to start in 1961. Shawinigan Engineering is slated to do the overall site planning and development. Atomic Energy of Canada, Ltd. is working with the Manitoba Development Authority on the project.

For more information, circle No. 138

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U.S.I. CHEMICAL NEWS

May ★ A Series for Chemists and Executives of the Solvents and Chemical Consuming Industries ★ 1960

New Electronic Process Is Said to Protect Steel From Many Corrosives

Sulfuric, nitric and phosphoric acids, caustic soda, aluminum sulfate, ammonium nitrate—these are some of the corrosive materials said to lose their sting indefinitely in steel vessels which have been subjected to anodic passivation techniques developed recently.

In the process, an electrode system and a newly developed automatic potential controller are used to form an extremely thin, oxygen-containing film over the steel, and to control this protective film electrically. The process was plant tested for a year, and it is claimed that corrosion in equipment during that period was completely eliminated.

In general, the process is said to be applicable to the oxy acids, bases and salts. The major class of electrolytes excluded are solutions containing halogens. It is reported that control can be established in very complex geometrical vessels, in flow lines, and at temperatures as high as 500° F.—by application of almost negligible currents. The developers of the process say that they can, by laboratory studies, predict the current and voltage requirements for anodically protecting any process or storage vessel.

New Sodium Peroxide Data Sheet Available from U.S.I.

Specifications, typical analysis, properties, shipping data and uses of U.S.I. sodium peroxide are included in a new technical data sheet now available from the company. The compound, which is used widely by the pulp and paper and textile industries for bleaching purposes, also has important applications in making organic and inorganic peroxygen compounds, in bleaching fats and oils, and in processing certain ores.

The new data sheet also offers technical service on sodium peroxide handling and use from U.S.I.'s staff and comprehensive laboratory facilities. For your copy, contact your nearest U.S.I. sales office or address Technical Literature Department, U.S.I. Chemical News, 99 Park Ave., N. Y. 16, N. Y.

New Aerosol Valve Can Operate at Any Angle

A new patented valve arrangement for aerosol containers allows operation at any container position by providing a by-pass to the dip tube which functions when the container is tipped. In an upright position, the by-pass is closed by a slider and the valve operates in the same way as any other—liquid being forced up the dip tube by propellant pressure.

In any inverted position, however, the slider falls away, the by-pass portion of the valve opens and the liquid, instead of going through the dip tube, flows into the by-pass and out through the conventional portion of the valve. The patented valve is essentially an adapter which may be used with some existing aerosol valves. Manufacturing licenses are being offered by the developer to valve producers in this country and abroad.

U.S.I. Introduces "MICROTHENE" Finely Divided Polyethylene

Resin in Powder Form Expected to Expand Use of Polyethylene In Textile, Paper, Metal, Chemical Specialty and Other Fields

Polyethylene in finely divided or powdered form is now being produced by U.S.I. and is available in sample and semi-commercial quantities under the tradename "MICROTHENE". Already in use in Europe, finely divided polyethylene is expected to open many new markets for the resin in this country and to expand a number of existing ones. Some of the applications forseen include its use as an additive in chemical specialties such as waxes and polishes, in the coating of metal, textile, paper, glass and wood products, as a binder for non-woven fabrics, and as molding powder for production of large polyethylene items such as boats, tanks, and shipping drums.

Methods of Application

In coating operations, MICROTHENE polyethylene can be applied to the substrate in its original powder form, as an organic or aqueous dispersion, or as an organic or aqueous paste. The method selected depends largely on the substrate to be coated, the major requirement being that the substrate be able to withstand the heat necessary to fuse the resin into a continuous coating. In the coating of woven and non-woven fabrics, dry polyethylene powder or a paste is generally spread evenly onto a moving web, which then passes through an oven to sinter the plastic into a film coating. Metal parts can be coated by spraying, dipping, or slush coating with either the dry powder or dispersions. Organic dispersions are generally used on metals that would be corroded by water. With modifications of application techniques, strippable polyethylene metal coatings may be possible.

Fluidized Bed Technique

Irregularly shaped objects, wire, and other metal items can also be coated with inex-

MORE

Healing Agent Solubilized By Ethanol in Aerosol Hair Sprays, After-Shaves

It has been suggested that panthenol—the alcohol analog of the B-complex vitamin pantothenic acid—be incorporated more widely into toiletry preparations because of its healing action with wounds, lesions and skin disorders generally. The material is a stable, biologically active form of pantothenic acid—one of the vitamins essential for growth and normal maintenance of skin and hair. It is said to be free of sensitation and irritation problems, and can be adsorbed topically to yield pantothenic acid in the body.

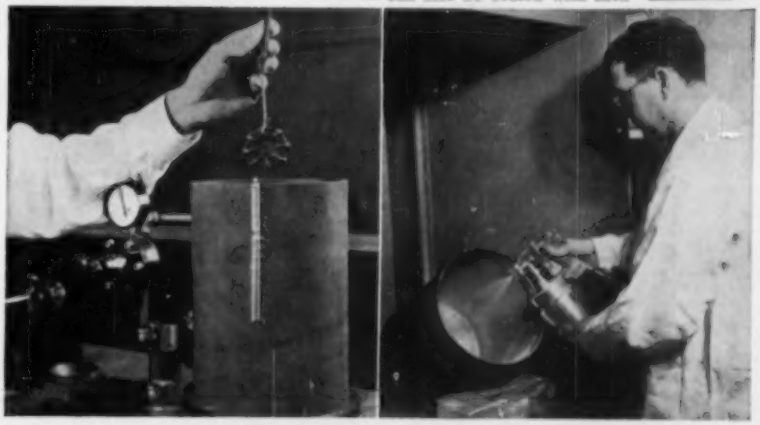
The following are two examples of formulations incorporating the healing agent:

(1) After-Shave Lotion

d-Panthenol	0.500%
Quaternary ammonium salt	0.250%
ALCOHOL (SDA-40)	40.000%
Menthol	0.005%
Ethyl p-aminobenzoate	0.025%
Distilled water	59.220%
Perfume	q.s.
Color	q.s.

(2) Aerosol Hair Spray

d- or dl-Panthenol	1.0%
Water-soluble lanolin	0.5%
Antistatic agent	0.1%
Perfume	q.s.
ALCOHOL (SDA-40)	28.4%
Propellants	70%



Two methods for coating metal with MICROTHENE finely divided polyethylene are shown above. Hot object is dipped in fluidized bed of MICROTHENE, left. Resin dispersed in organic liquid is applied by ordinary spray equipment, right.

CONTINUED

Polyethylene

pensive equipment employing the fluidized bed technique. The item is first preheated, dipped into a container with the fluidized dry powder, and then cooled or post-heated to achieve a smooth, continuous coating.

Plastic Moldings

Another potential market for MICROTHENE finely divided polyethylene is in the field of large plastic moldings. The powder is poured into heated molds which shape the polyethylene as it melts on the surface of the mold. Excess powder is then poured out. The molds required are extremely simple and inexpensive. Large containers, drums, and even small boats have been made successfully by this technique in Europe.

Production Facilities

U.S.I. is now producing MICROTHENE polyethylene at Tuscola, Illinois, site of one of U.S.I.'s two polyethylene plants. The MICROTHENE plant, which went on stream in March, has an initial capacity of 2 million pounds per year and is designed for fairly rapid expansion.

Technical Data Sheet giving detailed application information may be obtained by writing to Technical Literature Department, U.S.I. Chemical News, 99 Park Ave., N. Y. 16, N. Y. Samples are also available.

Sodium Cools Compact Reactor for Satellites

A miniature, sodium-cooled nuclear reactor, easy to scale up from 3 to 30 to 300 kw. with relatively little change in weight or size, has been developed to power communications systems in manned or unmanned satellites.

The 3 kw. version, which can power intermittent broadcasts from an unmanned satellite to the earth for as long as a year, could easily be lifted by present-day rockets. The reactor itself weighs only 220 pounds. Add an auxiliary power unit and the necessary shielding for an unmanned satellite, and the complete package weighs only 900 pounds. Larger rockets, promised for 1964, will be able to lift a *manned* satellite containing the reactor in its 3 or 30 kw. versions.

The reactor is relatively low in cost because it is fueled by uranium blended with zirconium hydride for slower burning. This fuel is contained in fuel elements in the reactor core. Liquid sodium coolant enters the core at 1,000° F., exits at 1,200° F., and transfers heat to a mercury loop. The mercury vaporizes to drive a small mercury vapor turbo-generator.

Although not completely finished yet, with the detailed engineering still to be worked out, this compact, sodium-cooled reactor is thought to be, at the moment, the most likely unit for powering communications in space.

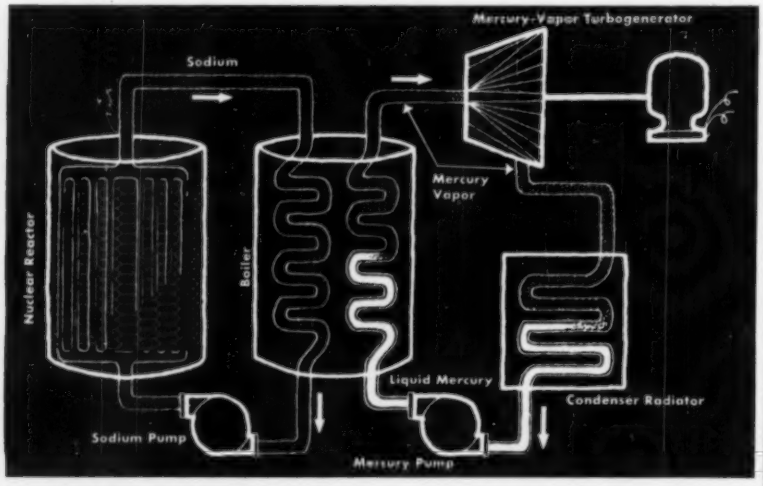


Diagram courtesy of Business Week magazine.

TECHNICAL DEVELOPMENTS

Information about manufacturers of these items may be obtained by writing U.S.I.

Analytical biochemistry is subject of new international journal now being published to serve biochemistry, biophysics and related areas of experimental biology. Devoted solely to papers describing methods in this area. **No. 1590**

Aerosol chromatography reagents now available from one source include aniline hydrogen phthalate, *p*-anisidine hydrochloride, bromcresol green, ferric chloride, isatin, ninhydrin. **No. 1591**

Protective coating now on market is said to remove rust chemically and to place a protective film over the surface—all in one operation. Can be applied to clean or rusted metal or previously painted surfaces, it is claimed. **No. 1592**

Research quantities of these chemicals are now available: hexanitroethane, trinitromethane, trinitroethanol, tetranitromethane, ammonium nitroform, potassium nitroform, hexanitrodiphenylamine, trinitrophenylmethylnitramine. **No. 1593**

New silicone fluids now available are unusually compatible with diversity of materials. Soluble in many aliphatic hydrocarbons, lower alcohols including ethanol; self-emulsifiable in water. Suggested for paints, cosmetics, other. **No. 1594**

Ammonium sulfate in a specially purified grade, designed for use as a reagent in enzyme research, is now being supplied. Product is said to have extremely low heavy-metal analysis, and to need no recrystallization. **No. 1595**

New magnetic stirrer capable of mixing and stirring solutions in as many as six vessels at one time has been announced. Solves problem of stirring several vessels simultaneously, at the exact same speeds. **No. 1596**

Seventh edition of the Merck Index, standard chemical reference book, can now be purchased. New edition has added tables in appendix, many expanded tables of data, 1600 new monographs on specific chemicals, many other additions. **No. 1597**

Report on sulfathiazole lozenges for preventing colds indicates that in a 6-year controlled study with 3,832 subjects, incidence of respiratory infections was ca. 15% in those using lozenges, ca. 57% in those not using them. **No. 1598**

Complete, low-cost radioisotope laboratory for teaching radioisotope applications in high schools and colleges is described in new bulletin. Lab consists of system of instruments, radiochemicals and lab accessories. **No. 1599**

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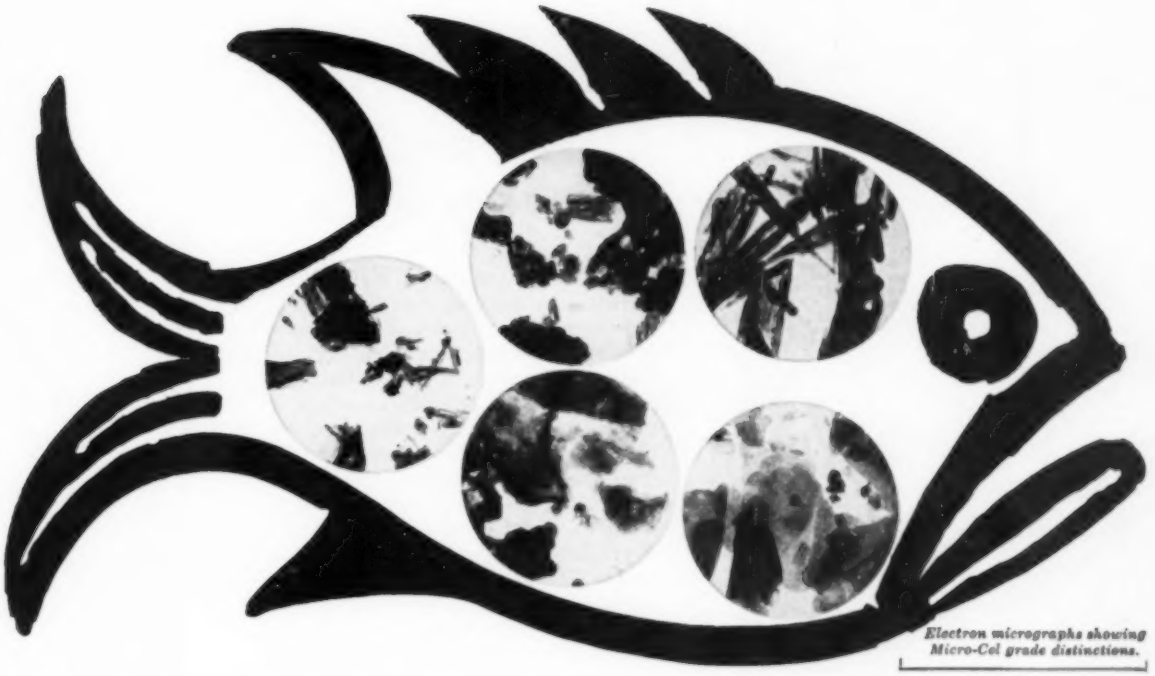

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Facets of Corrosion Research

Scientists in Argonne's Metallurgy Division are devoting time and energy to fundamental studies which shed new light on the mechanisms of corrosion of film-forming metals in pure water. Employing the basic research approach, a number of apparently fruitful avenues to tangible results are being explored. The Electron Microscope reveals that corrosion films can exhibit structural complexity not otherwise discovered. For example, under certain conditions the oxide film on an aluminum alloy grows as the complex maze of crystal filaments shown here. In another approach, a specially designed instrument measures polarized potentials and reveals details of corrosion processes. The accompanying polarization curves for pure aluminum in boiling water show the effect of the amount of electricity passed in the measurement.

Staff positions are available both at the site near Chicago, Illinois and the site near Idaho Falls, Idaho for qualified *physical metallurgists, chemical engineers, physicists, mechanical engineers, metallurgical engineers, chemists, electrical engineers, mathematicians, technical writers.*

Argonne
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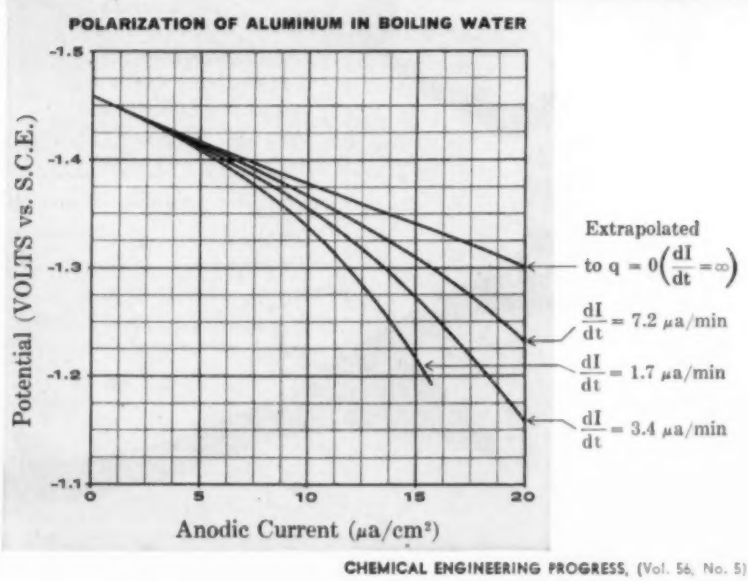
Operated by the University of Chicago under a contract with the United States Atomic Energy Commission

Direct inquiries to:
Louis A. Turner, Deputy Director
9700 South Cass Avenue—X5
Argonne, Illinois



WHAT IN THE HEAT TRANSFER WORLD

is happening in Buffalo next August ?

Once again, Heat Transfer gets the spotlight in the world of engineering . . . at the Hotel Statler in Buffalo, New York, August 14-17, 1960. Now in its fourth consecutive — and growing — year, the National Heat Transfer Conference and Exhibit will present the newest and best developments in the many diverse operations that make up this important field. Among the areas prominent in the program will be:

Design Procedures Related to Plant Operation • Oxide Fuel Heat Transfer • Heat Transfer in Advanced Reactor Concepts • Heat Exchanger Standardization

BE THERE! In the times in which we exist, it is important that you and other engineers keep as up-to-date as possible on the rapidly changing developments in the field of heat transfer. That is why it is important that you be at the conference in Buffalo.

MEMO TO EXHIBITORS: If you haven't already reserved exhibit space for this important show, *do so* today! For details and rates write or phone . . .

Paul A. Jolcuvar
Exhibits Manager, AIChE
25 West 45th Street
New York 36, New York
COlumbus 5-7330

Remember: **Fourth National Heat Transfer Conference and Exhibit**
Hotel Statler, Buffalo, New York
August 14-17, 1960

For a copy of the meeting program and hotel reservation card, write Mr. J. Henry, AIChE, 25 West 45th Street, New York 36, N. Y.

Chemical Engineering Progress

in the

July 1960 **HEAT TRANSFER ISSUE**

Closing Date: . . . . . June 15th, 1960

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For more information, turn to Data Service card, circle No. 29

equipment feature

High temperature bag filters

Operation at temperatures up to 600°F. made feasible by use of glass fiber bags and new cleaning techniques.

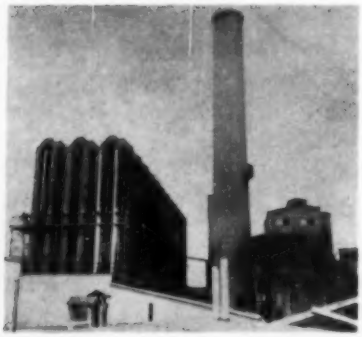


Figure 1. Glass-bag filter installation at Hudson Bay Mining and Smelting, Flin Flon, Manitoba.

TWO NEW GADGETS, one mechanical, one sonic, have licked the problem of using glass fabric in bag-type dust collectors, and have raised operating temperature limits for this type of filtration to about 600°F. Previous temperature limits with Dacron, Orlon, or Dynel fabrics were in the neighborhood of 250°F.

First successful large-scale use of the glass cloth fiber as a chemical process tool is at Hudson Bay Mining and Smelting, Flin Flon, Manitoba, where a 120-compartment glass-bag filter handles 450,000 cu. ft./min. of reverberatory furnace and converter gases. The system consists of twelve 10-compartment filters with a normal daily collection of over 35 tons. Gases are blown from an electrostatic precipitator, which receives the furnace and converter exhaust, to a series of cooling tubes where the temperature is reduced to 450°F, a full 150° less than the maximum advisable temperature for the filter.

The problem

Glass fiber has excellent corrosion resisting properties, and is far more heat resistant than conventional fibers. Chief disadvantage is its low flexural strength. Major problem, therefore, was the perfection of means for removing collected dust from the glass bags without subjecting the fibers to fracture-inducing shaking methods.

The solution

Development workers at the Dracco Division of the Fuller Company came up with two new bag-cleaning methods. The first, called "Swing-Clean," is a mechanical device which imparts a gentle oscillating motion to the top of the glass bags instead of the whipping motion typical of conventional shaking units. The second method, "Sonoclean," is a sonic unit consisting of low-frequency sound generators which cause the bags to vibrate. The vibration is not visible, but can be

continued on page 128

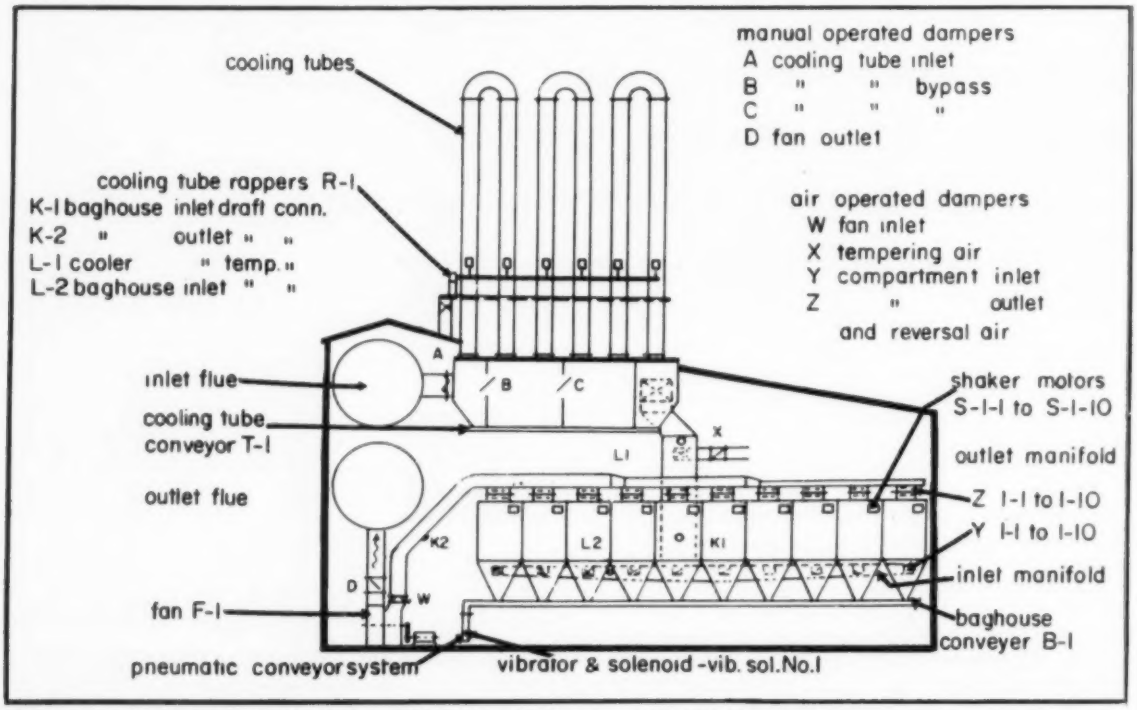
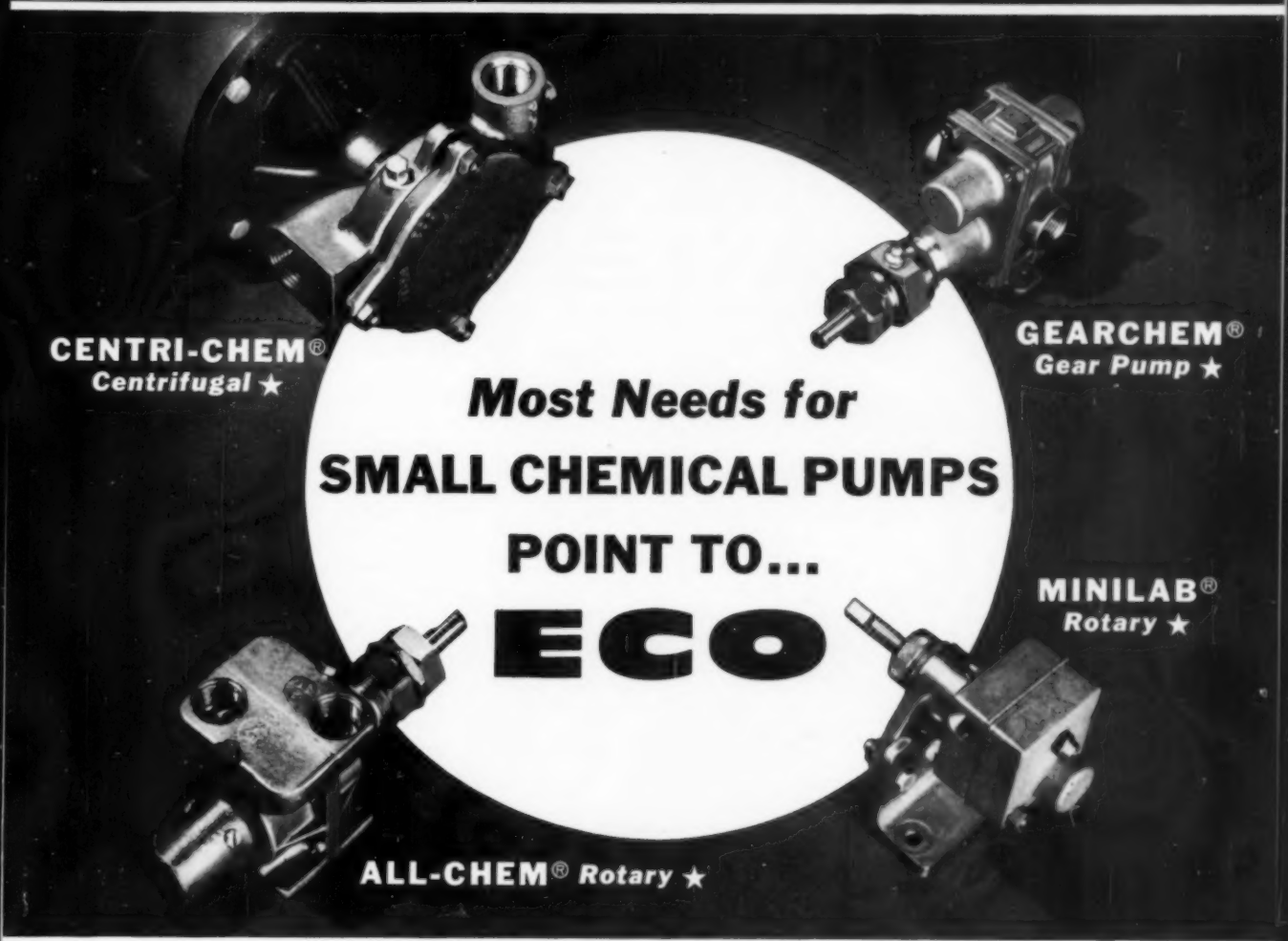


Figure 2. Sectional view of cooling train and glass-bag filter in use at the Flin Flon plant.

For more information, circle No. 43 ➤

ECO ENGINEERING NEWS

the big name in small pumps for the process industries



ROTARY: If you want linear, non-segmented, non-foaming flows, ideal for shear-sensitive emulsions and safe for auto-detonating fluids—select the self-priming Eco ALL-CHEM Rotary displacement pump with twin opposed oscillating impellers. Designed for severe corrosive service. For reduced viscosities and temperatures to 250° F. Capacities to 10 gpm. Pressures to 100 psi. Suitable for metering in conjunction with Rotometers.

CENTRIFUGAL: If you want a widely applicable, corrosive-resistant centrifugal pump handling most chemicals, including slurries with particle size up to ¼ of an inch, as well as troublesome sticky fluids—select the Eco CENTRI-CHEM Pump. This pump was designed to meet the standardization programs of major, multi-plant chemical companies. Capacities to 40 gpm. Heads to 57 feet.

GEAR: If you require self-priming and intermittent or sustained operation with constant flow metering and reproducible accuracy within plus or minus 1 percent, depending on viscosity—handling all commercial chemicals, acids, oxidants, alkalies, aromatics, solvents—select the Eco GEARCHEM Pump. For temperatures up to 400° F and viscosities to 10,000 SSU. Capacities to 10 gpm. Pressures to 100 psi.

GREAT VERSATILITY

The widest variety of metals and nonmetallics for every corrosion and contamination problem are utilized in Eco Pumps. These include the stainless steels, Stellite*, Hastelloy* B and C, monel, nickel, zirconium and titanium; Teflon†, phenolic plastics, Hypalon†, Nylon, Pentonx, ceramic, carbon, etc.

Mass Produced and Stocked for Immediate Delivery

Eco Pumps are *not* "custom built" with attendant slow delivery and high cost.

They are stock pumps, produced in volume on automatic "program" machine tools where multiple operations are performed to reduce needless labor and handling. This results in lower prices, precision uniformity and complete interchangeability of parts to meet customer requirements and to facilitate field servicing.

Ask for literature on the complete Eco pump line.

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Newark Standard Testing Sieves are available in a complete range of sizes and we shall be glad to recommend the best range of meshes for your particular requirements.

Newark Wire Cloth COMPANY

351 VERONA AVENUE • NEWARK 4, NEW JERSEY

For more information, turn to Data Service card, circle No. 13

Bag Filters

from page 126

felt by touching the bags. Noise level is said not to be objectionable outside of the filter compartment. The mechanical method is reported to function best with light flocculent dusts that are difficult to remove, while the sonic method works better on heavier, denser dusts.

Operating experience

The Hudson Bay installation has now been in commercial operation for over 30 months. Many of the original bags are reported to be still in use. Significant economies are claimed, also, in the reduction by more than 50% of the primary cost of cooling facilities, made possible by the higher operating temperatures feasible with the new filtration medium. A further important contribution is protection of metal and masonry surfaces from corrosive attack by condensed gases, the so-called "acid dews."

A boost in methanol and formaldehyde capacity is planned by Allied Chemical's Nitrogen Division. Methanol increase will be 50 percent, formaldehyde, 35 percent.

A 24,000 ton-per-year tall oil refining plant planned by Heyden Newport will be the company's second. The Oakdale, La., unit will produce tall oil rosins and fatty acids, and distilled tall oils. Contract for the plant, due to go on stream early in 1961, went to Foster Wheeler.

A production facility for propylene oxide and derivatives will be constructed at Priolo, Sicily. The 25 million pounds a year facility will be operated by S.p.A. Celene, jointly owned by Union Carbide and Societa Edison of Milan. Celene's initial polyethylene plant is now being expanded to 65 million pounds annually. Solvent and plasticizer facilities are also under construction at the site.

The Meaker Company, purchased by Sel-Rex Corporation, will operate as a wholly owned subsidiary. Meaker, manufacturer of automatic systems for continuous and batch metal processing, will expand its facilities to diversify current product lines.

A substantial expansion in ethylene capacity takes place at Phillips Chemical. A new plant next to its existing facility at Sweeny, Texas, will supply the Texas Gulf coast market. Present capacity of 290 million pounds will double when construction is complete in late 1961.

HYPALON® TANK LININGS KEEP CAUSTIC SODA IRON-FREE AT 285° F.

A major producer of caustic soda has operated nine experimental tank cars since February, 1957. These cars were sprayed with an 8-10 mil thickness of HYPALON. Results after nearly three years: HYPALON lining has retained its light color and smooth finish. The spray coating in the tank car at right was recently inspected. It has withstood 50% and 73% caustic soda shipped at temperatures as high as 285°F. and still needs no maintenance.

Tank linings made from HYPALON can handle highly oxidizing acids at temperatures that would quickly destroy other types of rubber linings. Because of their unique resistance to oxidation, HYPALON linings have gained recognition in handling chemicals like calcium and sodium hypochlorites, chromic acid (50%), phosphoric acid (85%), sulfuric acid (80%), nitric acid (30%) and various pickling acid solutions.

HYPALON is resistant to corrosive chemicals, abrasion, ozone, sunlight, weather, high temperature (up to 350°F.)—all this plus its flame resistance and permanent colorability—make it an extremely versatile elastomer. Rubber maintenance products which offer the long-term economy of Du Pont HYPALON and neoprene are available from your local rubber goods distributor. He can suggest the right product for any job you need performed. Take advantage of his experience and services soon.

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For additional information write for "Du Pont Elastomers in Industry" and a free subscription to the "Elastomers Notebook."

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Better Things for Better Living . . . *through Chemistry*

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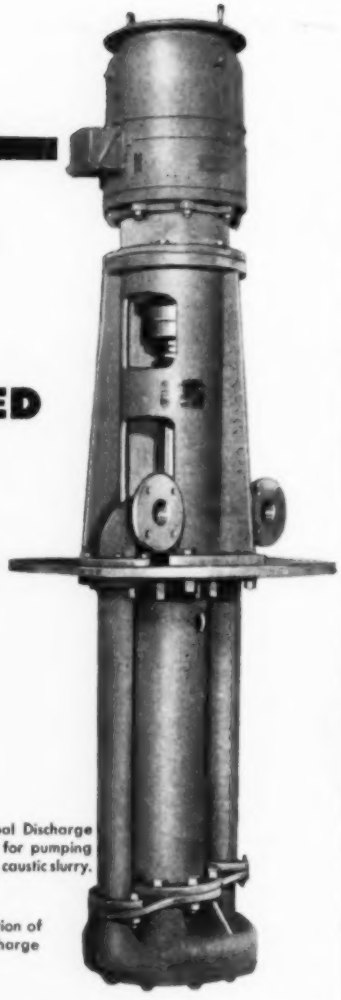
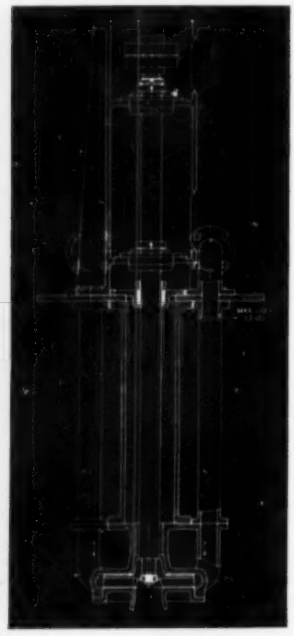
VERTICAL PUMPS WITH NO SUBMERGED BEARINGS FOR PUMPING ABRASIVE CORROSIVE SLURRIES





2" Dual Discharge Pump for pumping molten caustic slurry.

Cross section of Dual Discharge Pump.

This rugged type of service calls for advanced design: — extra heavy shaft, double-ported casing to equalize the side thrust of the impeller, and tough abrasion-corrosion resistant alloys. The dual discharge pump illustrated here incorporates these features and dispenses with bearings or packing below the cover plate where they would be in contact with the liquid.

Difficult pumping problems, particularly in the process industries, have been our specialty for ninety-one years. Perhaps we can be of help to you. Write us — no obligation.

LAWRENCE PUMPS INC.

371 MARKET STREET, LAWRENCE, MASS.

For more information, turn to Data Service card, circle No. 108

industrial news

New detergent alkylate on stream

A NEW DETERGENT ALKYLATE will go into full scale production at the newly completed plant of Oronite Chemical in Richmond, California, one of the largest detergent polymer facilities in the world.

The detergent alkylate, tradenamed Alkane 60, will, according to the company, boost detergent foaming and cleaning power as compared with the more conventional dodecyl benzene products. The improved properties of the polymer are said to stem from the increase in molecular weight.

The molecule's average carbon side chain is made up of thirteen carbon atoms. This is said to prompt greater foaming and improved detergency. Increased foaming action minimizes the need for costly suds boosters, and, it is expected, will cut production costs for detergent manufacturers.

High purity of Alkane 60, it is reported, will mean excellent yield during processing, and good color for the detergent sulfonate. Extensive laboratory tests show that the Alkane 60 can be processed just as easily as other detergent alkylates despite its greater molecular weight. It requires no new equipment, and no modification of standard detergent production techniques.

New foreign subsidiary formed by Catalytic Combustion has offices and factory at GondsrothHessen, West Germany. The company, Kavag, will manufacture catalysts and catalytic combustion systems, under patent license from the parent company. With the increasing emphasis on air pollution control in many European countries, the catalytic combustion equipment is expected to be of particular value to the larger plants having processes releasing volumes of noxious waste gases.

For more information, circle No. 97

Fill your surfactant needs

from CARBIDE'S 9 TERGITOL nonionics

Take your choice from CARBIDE's TERGITOL nonionics—one that is completely soluble in oil . . . another that dissolves in water at high temperatures . . . or one with a combination of characteristics. TERGITOL nonionics have outstanding capacity to emulsify oils, waxes, and greasy soils—to hold them in suspension. As wetting agents, TERGITOL nonionics are noted for their chemical stability in the presence of acids and salts. They are not affected by hard water or alkalies.

TERGITOL nonionics have proved effective in scouring, bleaching, and carbonizing compounds used by the textile industry. As detergents, they speed dishwashing, laundering, dry cleaning. They give good pigment dispersion, flow-out, and stability to latex paints. Metal cleaners, leather dressings, silicone preparations, shampoos, adhesives, bactericides—all can be improved with TERGITOL nonionics.

Cloud Points of 0.5% aqueous TERGITOL Nonionic Solutions (Degrees C.)

NP-14	Insoluble
NP-27	20
TP-9	51-56
NPX	60-65
NP-35	90-95
NP-40	100
TMN	35-37
XD	60-65
XH	90-100

You can obtain TERGITOL nonionics in 55-gal. drums, combination car load or truck load lots, or compartment tank car shipments. Your CARBIDE Technical Representative can help you solve your surfactant problems. Or write Dept. HC, Union Carbide Chemicals Company, Division of Union Carbide Corporation, 270 Park Avenue, New York 17, N. Y.

TERGITOL and UNION CARBIDE are registered trade marks.

UNION CARBIDE CHEMICALS COMPANY

UNION CARBIDE

meeting preview

ENRIQUE RANGEL
Dow Chemical Company
Mexico, D.F., Mexico

Meet Latin America in Mexico

One of the biggest international chemical engineering meetings of this or any year takes place June 19-22 in Mexico City—Here are the last-minute highlights.

THE UNIQUE ATMOSPHERE of Mexico will flavor and enhance the entire International Meeting June 19-22. The Instituto Mexicano de Ingenieros Quimicos, joint hosts with A.I.Ch.E. at the Mexico City gathering, have gone all out to make it informative *and* entertaining. Visitors to the meeting will be treated to an extensive review of the chemical engineering field since the technical program takes in aspects of chemical engineering ranging from problems in Latin America to cryogenics.

A word on the weather: While Mexico City is in the tropics, because of its altitude it is apt to be more on the cool than the warm side. Also, be prepared to adjust timewise to the Latin American way of conducting business. Most of the afternoon sessions start late and run until 6:30 or 7:00 PM.

A special treat is in store for those who attend the gathering. The president of Mexico, Lopez Mateos, will attend the inauguration ceremony Sunday afternoon.

Bullfight

Since Mexico is famous for its bullfights, and for possessing the largest bullring in the world, what visit, whether for convention or vacation purposes, would be complete without one? The A.I.Ch.E. meeting is no exception. Wednesday afternoon, after the technical sessions are over, attendance has been arranged at a Bullfight Festival at Rancho Tapatia.

Time out from the meeting is not necessary in order to see the internationally famous National University of Mexico. Some of the sessions, including those on *Chemical Engineering Education in the Americas*, *Machine Computation* and the *Student Program*, will be held at fabled University City. The first University in the new world, founded in 1553, has today an enrollment of more than 45,000. Along with National Polytechnic Institute, it turns out 150 of the 250 chemical engineers that Mexico produces each year. University City keeps in the architecture of its laboratories, schools of engineering, law and medicine, the unmistakable seal of the ancient cultures of the Aztecs. Its stadium is said by many to be the most beautiful in the world, and the landscaping of the buildings is a peculiar combination of modern and ancient.

Engineers observe operations at the Atzcapotzalco refinery of Petroleos Mexicanos.

Distillation symposium

On the technical program, and not previously listed as part of the Distillation Symposium, is a paper, *Vacuum Compression Distillation Column*, by Donald F. Othmer and Robert D. Beattie. This is a description of a new type of vacuum fractionator. Considerable interest has been expressed in this fractionating device for use in the pharmaceutical and fine chemical business, and by chemical engineers in the petroleum industry. The principle reason is because it is possible to have lower pressures in the reboilers than in the condenser. More than 100 percent Murphree efficiencies can be obtained per stage, due to the counter current action within the stage proper.

Another highly successful feature of past national meetings will be continued in the unit operations luncheon. Here is an opportunity to meet informally with experts in various aspects of the field for exchange of information.

Ladies' program

On the ladies' program is a tour of Mexico City, and a tour of University City. Also lined up are a trip through Xochimilco, the famous floating gardens where the flower vendors paddle up and down the canals in kayak-like chalupa (dugout canoes). Capping the tours is a visit to the Pedregal residential section, where beautiful modern homes are landscaped in the natural volcanic rock.

Socially, members will not even need to leave the meeting ground to spend an evening enjoying Mexican culture. *Noche Mexicana*, an evening planned by the arrangements committee, is devoted to Mexican music, dances, costumes, food and drink.

Plant tours

Plant trips for this meeting are of more than usual interest, for a picture of the outstanding development of Mexican industry during the past few years can be gained by this representative viewing of industrial plants. The growth is reflected mainly in the Mexico City area, where as much as 50 percent of the total industry is installed, with respect to peso volume. (Incidentally, Mexican currency at the present rate of exchange is 12½ pesos for one dollar. One peso is equivalent to 8¢ in U.S. currency). A partial listing of plant trips scheduled follows:

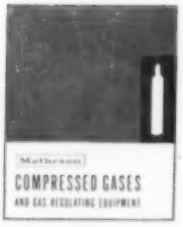
continued on page 134

MATHESON

Compressed Gas Notes

New Listings from our 1960 Catalog

Here are highlights of items listed for the first time in the new Matheson Catalog, published last month. This catalog contains prices and data on 85 compressed gases and gas mixtures and a complete line of gas regulating equipment. Write for your free copy.



Perfluoropropane

Shows potentials of acting as an excellent gaseous dielectric. The breakdown voltage of Perfluoropropane is about the same as Sulfur Hexafluoride, and under certain conditions can be approximately 20% greater than that for Sulfur Hexafluoride. The thermal and chemical stability also sets it apart as a good gaseous dielectric. Mail coupon for Bulletin.

Perfluorobutene-2 (cis & trans)

The most promising uses for this newly produced compound are in copolymerization with commercially available monomers for improved characteristics.

Ethane (C.P.)

Up to now The Matheson Company has supplied a technical grade of Ethane with a minimum purity of 95 mol %. This purer grade of Ethane should prove of value to those doing research work and specialized work requiring a material with a 99 mol % minimum specification.

Ultra Pure Hydrogen

Guaranteed less than 10 ppm total impurities, this gas is ideal for special treatment of metals very sensitive to oxidation. Typical analysis on this gas usually shows less than 1 ppm total impurities.

Nitrogen Trioxide

The Matheson Company is now offering this material as a stock item after manufacturing it for a number of years on a custom basis. It is recognized as a possible rocket fuel oxidizer.

1, 1-Difluoroethylene

This gas, newly introduced by The Matheson Company, should be of distinct interest to those in the plastics field due to its polymerization and copolymerization potentialities.

Fluorine

This most powerful oxidizing agent is now supplied in ½ lb. net containers by The Matheson Company. A complete line of equipment has been developed to simplify the handling procedures for this active gas. Mail coupon for data sheets and equipment lists.

Vacuum Regulator

This regulator is used for maintaining a definite vacuum with cylinder or pipe line gases. It is useful for controlled atmospheres in vacuum systems.

Line Filters

Used for removing scale or dirt particles larger than 25 microns from gas or liquid lines to protect regulators, meters and valves.

High Pressure Corrosion Resistant Regulator

For a number of years The Matheson Company's #15 corrosion resistant regulator has proved of extreme value for handling Chlorine, Hydrogen Chloride, Hydrogen Bromide and Boron Trifluoride up to a minimum delivery pressure of 50 p.s.i.g. We are now introducing a high pressure regulator of the same materials of construction and design as the #15 with an extended range of delivery pressures up to 650 p.s.i.g.

Automatic Switching Manifolds

The Matheson Company's expanded line of manifolds and manifold parts makes available custom made manifolds to suit your particular needs. Of extreme usefulness is Matheson's new automatic switching manifold which allows automatic switching from one bank of cylinders to another without an operator in attendance.

Expanded line of radioactive gases

Matheson's experience in the handling of compressed gases and gas mixtures, along with two years of experience in the handling of radioactive gaseous tracers makes available an expanded line of Carbon-14 gases, Krypton 85, Sulfur 35 and tritiated gases for tracer studies, leak detection, heart shunt studies and electronic discharge tube filling gases.

New line of flowmeters

Experience in the handling of over 80 different gases has enabled The Matheson Company to develop a complete line of new flowmeters featuring complete tube interchangeability for practically all liquid and gas services. Mail coupon for our new pamphlet featuring laboratory flowmeters.

The Matheson Company, Inc., P.O. Box 85-B, East Rutherford, N.J.

Please send the following:

- ☐ New Matheson Compressed Gas Catalog
- ☐ Perfluoropropane Bulletin
- ☐ Fluorine Bulletin
- ☐ Flowmeter Pamphlet

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Compressed Gases and Regulators

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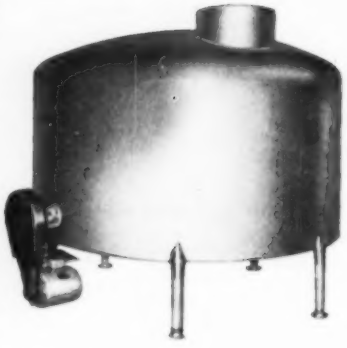

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Mexico meeting

from page 132

The Sosa Texcoco, one of the first heavy chemical industries set up in Mexico, supplies 250 tons a day caustic soda and 100 soda ash.

The Brewery of Cerveceria Modelo, eighth largest brewery in the world.

The Guanos y Fertilizantes Cuantitlan plant, produces ammonium sulfate. Starting operations in 1950, it represented the first effort of the Mexican government to meet the growing demand for synthetic fertilizers in Mexico.

The mill of Cia. Industrial de San Cristobal. This is one of the most important mills on an international scale, manufacturing pulp and paper from sugar cane bagasse. It produces more than 100 tons a day of bleached pulp.

The Atzcapotzalco Refinery of Petroleas Mexicanos, supplies the fuel needs of Mexico City and the surrounding area. It refines 100,000 bbls/day of medium and heavy fuels, and 30,000 of gasolines for automotive and aviation use.

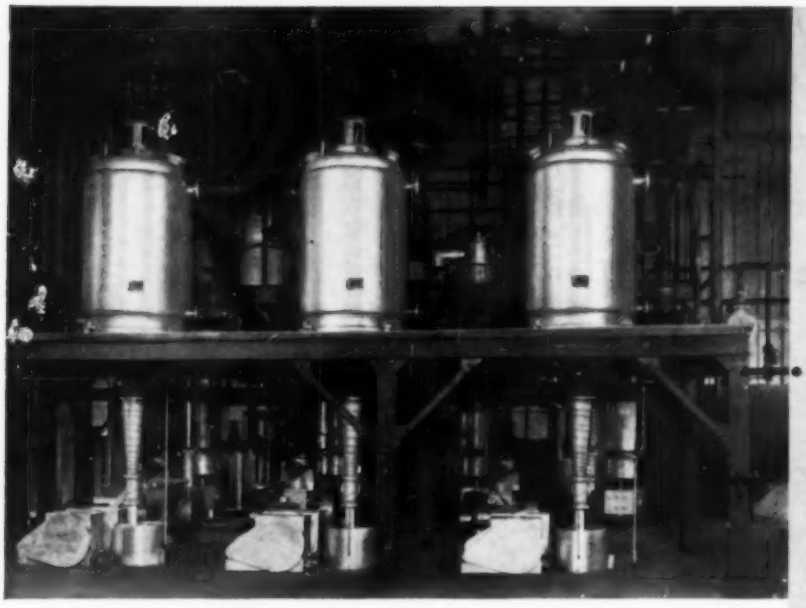
Requirements for entry into Mexico

You must carry:

1. A Mexican Tourist Card. This can be obtained upon application to the Mexican Consulate in any principal city of the United States, and also from any Mexican Government Tourist Bureau.*
2. A document proving U.S. citizenship. This can be a birth certificate, voter's certificate, passport, or the like. Naturalized citizens should take their papers with them. U.S. citizens need no passports, but resident aliens must

continued on page 137

Pegasus looks up at the Torre Latino Americana one of Mexico's tallest buildings.



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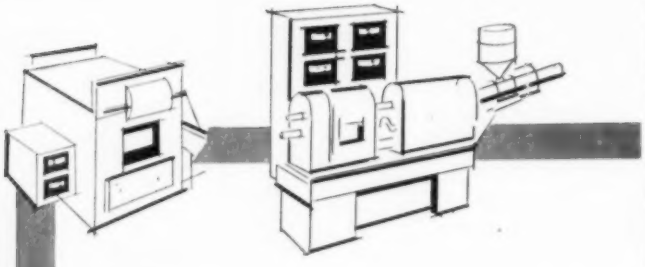

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Entry requirements

from page 134

have both passports and alien registration cards.

3. A smallpox vaccination certificate less than three years old. This is required for re-entry into the United States.

The United States Travel Agency in Washington, D.C. has arranged special flights from major areas in the United States for engineers who may want to travel together. The Agency has offered to take care of all the details of the trip, including supplying Tourist Card application forms, for members taking one of these flights from Seattle, Portland, San Francisco, Los Angeles, Chicago, Dallas, Boston, New York, Washington, Atlanta, and New Orleans. These flights will arrive in Mexico City on Saturday, June 18. Simply request United States Travel Agency, Inc., 807 15 Street N.W., Washington 5, D.C. for necessary forms and travel reservations.

For those attending the meeting who want to stay over and sightsee a bit, U.S. Travel has also set up a series of post-convention trips, all starting Thursday, June 23. Lined up are guided tours to:

Taxco and Acapulco, $138.50 per person, ends June 26.

The Gulf Tropics, (Fortin de las Flores), Panafiel, Puebla, Cuernavaca, Taxco and Acapulco, $219.75 per person, ends July 1.

Uxmal, home of the Maya Indians of Yucatan, Merida, Chichen Itza, $268.75 per person, ends June 28.

**The Mexican Government Tourist Bureaus in the United States: 8 West 51 Street, New York, N.Y.; 27 East Monroe, Chicago 27, Illinois; 735 S. Olive, Los Angeles, California; 518 West Houston, San Antonio, Texas; Columbus Hotel, Miami, Florida; 203 Charles, New Orleans, Louisiana; 901-3 Bank of America Building, San Diego, California; 142 Mellie Esperson Building, Houston, Texas. Other offices are: 26 College, Toronto, Canada; 1255 Phillips Square, Montreal, Canada; Calle 23 No. 72, Vedado, Havana, Cuba.*

For more information, circle No. 20

One of a series

Catching Up with a Slippery Equation

What goes on when two moving surfaces are separated by a film of oil?

Simple question? Maybe, but engineers and mathematicians have been trying to answer this classic question of lubrication ever since Osborne Reynolds neatly stated the problem in equation form back in 1886.

Unfortunately, analytical methods for solving Professor Reynolds' partial differential equation worked only for unrealistic oil bearings, bearings with widths approaching zero or infinity. And approximate methods were crude, requiring a complete recalculation for each slight change in the bearing.

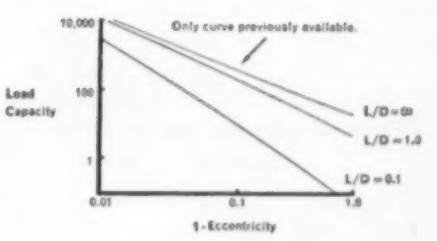
Recently, mathematicians at the General Motors Research Laboratories came up with the most versatile and efficient method of solution yet made. Their analytical method for solving the two-dimensional Reynolds' equation applies to all finite journal bearings – as well as other hydrodynamic bearings – with *no* assumptions or approximations about boundary locations. The new method uses a long-neglected energy theorem recorded by Sir Horace Lamb instead of the force relationship tried by Reynolds and others.

Besides being a valuable contribution to the theory of lubrication, this work has its practical side: namely, accurate, serviceable design curves for engineers. At GM Research, we believe delving into both the theoretical and applied sides of a problem is important to progress. It is a way of research that helps General Motors fulfill its pledge of "more and better things for more people."

General Motors Research Laboratories

Warren, Michigan

Hydrodynamic analyses have led to specific answers about bearing operation. Shown here are the oil pressure distribution (main illustration) and load-carrying capacity for a non-rotating journal with a reciprocating load.



industrial focus

R. F. Selm & B. T. Hulse

Deep well disposal of industrial wastes

Comparative economics of deep well disposal versus chemical or biological treatment facilities can be a complex problem.

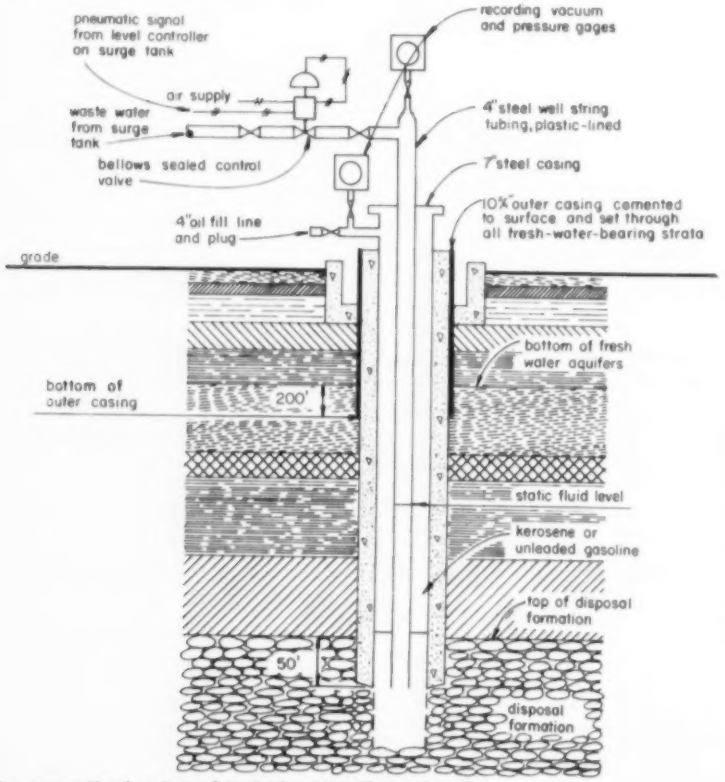
Approval of regulatory agencies, municipal or state, is a primary consideration when a disposal well is proposed. The approving agency will usually require answers to the following questions:

- What is the probability for long term success?
- Would the waste in question be suitable for surface reuse after reasonable treatment, or does it represent water which will be permanently lost?
- Does the proposed disposal well adequately safeguard the fresh water formations through which it extends?

Experience records in the disposal of oil field brines show that similar brines can become incompatible. Prediction of the complex chemical equilibria in a multicomponent brine in a formation at a pressure of the order of 100 atmospheres or more, and a temperature of approximately 140 to 170°F, is a difficult problem. The problem, however, may be solved in a qualitative way, by pretreatment of the wastes.

Certain general rules may be laid down:

1) The waste should have a pH at least one-half a unit below that of the receiving brine;


pneumatic signal from level controller on surge tank
air supply
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bellows sealed control valve
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recording vacuum and pressure gages
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7" steel casing
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grade
bottom of fresh water aquifers
bottom of outer casing
200'
static fluid level
kerosene or unleaded gasoline
top of disposal formation
50'
disposal formation

Diagrammatic drawing of typical waste disposal well.

2) It should be relatively free from dissolved or entrained air or oxygen;

3) It should be free from hydrogen sulfide and sulfur dioxide, and should be neither oxidizing nor strongly reducing;

4) It should be free from heavy metal ions, or other ions capable of forming precipitates by reduction, neutralization, or metathesis;

5) It should be sterile, free from bacteria, algae, or fungi;

6) It should be free from organic materials which might polymerize, decompose, precipitate, or become viscous;

7) Safeguards should be provided to assure that the well head is not subject to air leakage.

Well construction details

Legal implications involved in the contamination of fresh water aquifers are so serious that every precaution should be taken to avoid the possibility. Certain design features are recommended to protect the fresh water formations.

The well string should be protected by an outer well casing set through the impervious layers to the disposal formations, and should be cemented from the surface. The annular space between the disposal well string tubing and this well casing is filled with a 60-degree API unleaded gasoline or kerosene. The hydrocarbon will be held under pressure by the fluid level of brine in the well. This pressure is recorded on a gauge at the well head, and provides a record of the operating water level in the disposal casing.

The outer well casing should be protected by still another large casing extending through at least 200 feet below the lowest fresh water formation. This casing also should be cemented for further protection of the aquifers.

The inner disposal casing is equipped with a vacuum gauge and gauge valve. Valves should be bellows-

continued on page 140

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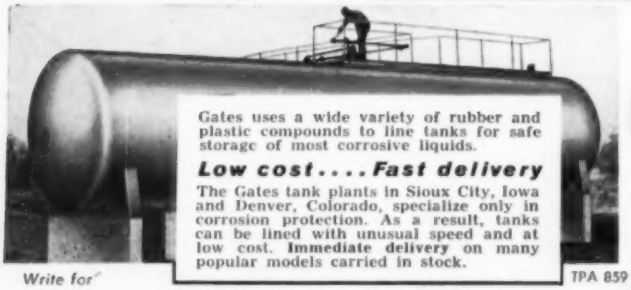
Safe storage for corrosive liquids...



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For more information, turn to Data Service card, circle No. 80

Deep well disposal

from page 138

seated to assure that no air can be drawn into the well; this precaution applies particularly to the input control valve, if used.

The injection into the well should be made from a covered storage tank with a capacity of at least 48 hours flow into the well. The tank is operated at a preset low level by an interface controller which uses a 2-foot layer of 30-degree API gas oil as an air seal. A falling interface level closes the control valve leading into the well. This control valve, the auxiliary block valves, and all connections are made vacuum tight by bellows seals or welded connections.

Sampling wells should be installed adjacent to the disposal well, and should penetrate into the lower depths of the fresh water formations so that water samples may be taken for periodic analysis.

Chemical incompatibility

Chemical incompatibility between formation brines and injection water exists when a chemical reaction between the two produces a precipitate or deposit, or releases a gas. Reactions which can cause plugging precipitates can be classified:

Class 1—Alkaline earth precipitates

The alkaline earth metals, calcium, barium, and strontium, all have relatively insoluble carbonates, sulfates, phosphates, and fluorides. The carbonate, hydroxide, and fluoride of magnesium are also relatively insoluble. Prevalence of these alkaline earth metal ions in formation brines requires careful consideration of the anions which will combine with them. Thus, a formation brine containing barium ions will not be compatible with sulfate-bearing wastes. A table of solubility products for these compounds may be used to estimate the allowable ion concentrations. These solubility products will become increasingly conservative as the chloride concentration increases.

Class 2—Heavy metal precipitates

Presence of the heavy metals in industrial wastes, except for iron, aluminum, and manganese, is usually due to processing losses. Such metals may include iron, aluminum, manganese, chromium, nickel, cadmium, zinc, and copper.

Iron salts may be present in process wastes such as pickling acid; they are also found as corrosion products of

continued on page 142

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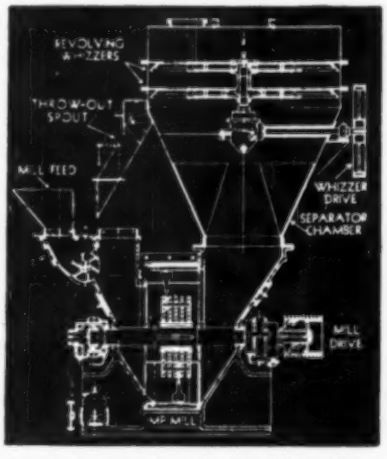

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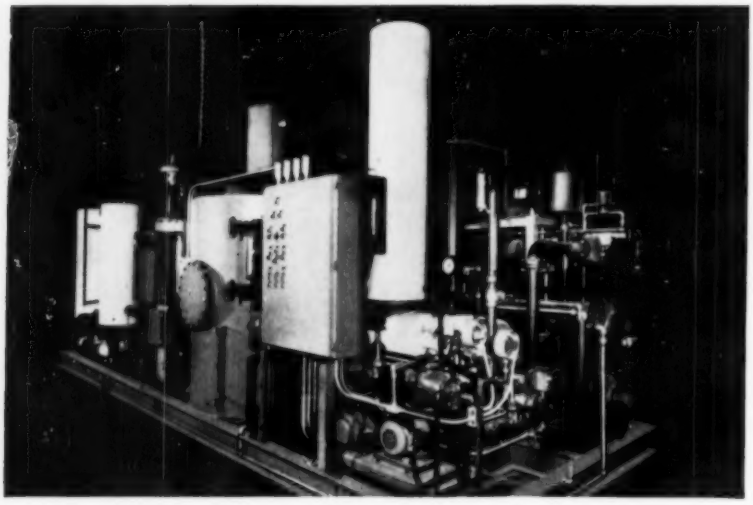

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Deep well disposal

from page 140

gathering lines or well casings. Iron is particularly prone to cause plugging in sand formations, and has been the direct cause of the failure of many injection wells. The hydroxides, sulfides, and carbonates of both valance states are quite insoluble. Since the most prevalent iron contamination is due to oxygen attack on the well casing or tubing, rigid removal and exclusion of oxygen, addition of sequestrants, such as citric acid, and use of corrosion inhibitors are suggested.

Aluminum is found as a process waste from metal-finishing operations, and as a carryover floc from water treating operations.

Manganese will normally be removed with iron by aeration and chlorination followed by settling and/or filtration.

Class 3—Oxidation-reduction pricipitates

These pricipitates are usually the oxidation-reduction reaction products of hydrogen sulfide with some injection oxidizing agent. Probably the most troublesome reaction of this type is the oxidation of hydrogen sulfide to sulfur by the reduction of chromate or dichromate to chromic hydroxide. Widespread use of hexavalent chromium compounds as oxidation inhibitors in cooling water has made this ion common in waters considered for well disposal. The difficulty of removing dilute chromates in the range of 0.1 to 10 ppm by reduction with sulfur dioxide or low pH has, in some cases, made deep well disposal attractive.

Class 4—Organic polymers

Wastes from resin manufacturing facilities, pharmaceutical plants, food processing plants, and many other types of chemical plants, will occasionally contain resin-like materials which, under the formation pressure and temperature, may polymerize to form solids which can plug underground formations.

Class 5—Suspended solids

Bacteria and algae growths can effectively block an underground formation, as can any suspended solid, dirt, oil, or grease. A maximum turbidity of 1 ppm is recommended.

Class 6—Bacteria

Sulfates can be decomposed by sulfate-reducing bacteria in reactions involving reduction of sulfate ion to hydrogen sulfide. These organisms

continued on page 144

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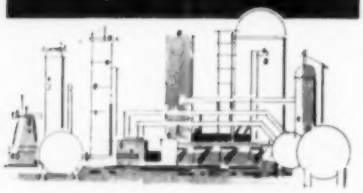
AIR LIQUIDE
ENGINEERING & CONSTRUCTION DIVISION
OLDEST IN EXPERIENCE — NEWEST IN DESIGN

405 LEXINGTON AVE., NEW YORK 17, N.Y.

For more information, turn to Data Service card, circle No. 77

TRANSALL® Pre-Lubricated Idlers...



Savings for the Chemical Industry

Transall pre-lubricated idlers are the product of years of experience in manufacturing belt conveyors for the chemical industry. Bearings of Transall Pre-Lubricated Conveyor Idlers are factory sealed —never require re-lubrication. More important, perhaps, there is no leaking grease to deteriorate your conveyor belt. Entry of abrasive dust, foreign matter, etc., is kept to a minimum to prevent destruction of bearings, the heart of an idler. **Result:** No lubricating costs, longer belt life, idlers last longer, maintenance costs less.

Idlers are available in 20°, 35° and 45° equal and unequal length rolls with various roll diameters and thickness of tubing wall.

We also manufacture complete pre-engineered sectional belt conveyor systems. Write or wire Transall Inc., 109 No. 11th, Birmingham, Alabama, for complete details.

Perfectors of the Pre-Lubricated Idler

TRANSALL, INC.
109 North 11th St. • P. O. Box 1588
BIRMINGHAM ALABAMA

For more information, circle No. 113

Deep well disposal

from page 142

can be controlled by bacteriacides but, in some cases, the procedure may be so costly as to warrant surface disposal.

Economics

Deep disposal wells can be very expensive. The cost depends on the pretreatment required, depth of the hole, corrosivity of the waste, state regulations, nature of the formation, etc. Unless high total dissolved salt concentrations are present, the method will not ordinarily be competitive with surface disposal processes, chemical or geological. A rough rule is that a single well installation should be able to dispose of 500 million gallons of waste to be on an equal first-cost basis with a biological or chemical treatment facility. In some cases, the waste may require even more extensive chemical treatment for injection than for surface disposal.

Waste disposal wells normally cost between $50,000 and $250,000 for each wellhead. Average flow capacity for a 4-inch well string receiving conditioned water should be estimated at about 200 gal./min.

A 30 million pound a year carbon black plant to be constructed at Bakersfield, Cal., by Continental Carbon, is one of the first of its type on the west coast. The oil furnace black facility is expected to service the growing west coast carbon black market.

A 10 percent expansion in the synthetic rubber copolymer plant of Texas-U.S. Chemical Co. (Texus), Port Neches, Texas, will increase output to 156,000 long tons annually. The additional drying and carbon black masterbatch facilities are due for completion late this year.

Arthur G. McKee, engineering and construction firm, has formed two operating subsidiaries, A. G. McKee de Mexico, and another in Brazil.

Polyurethane resins for coatings and adhesives will be manufactured in the newly formed Plastics Division of Trancoa Chemical, Reading, Mass.

Pennsalt will triple production of alkyl and alkanol amines. A $1.5 million plant at the company's Wyandotte, Michigan, works will use a completely continuous process, which produces several different alkyl alkanol amines. On stream date is the end of 1960.

BALANCED

Sel-Rex®

CUSTOM ENGINEERED RECTIFICATION

- *Germanium*
- *Silicon*
- *Selenium*

No more tedious matching of cell characteristics when replacing a damaged semiconductor in a rectifier system. Sel-Rex Balancing Reactors *force even distribution of the load among all rectifying elements* — regardless of individual cell characteristics. Simply replace damaged elements with ones which are similarly rated. Another example of Sel-Rex "Custom-Engineering."

Send for FREE "GUIDE" to Industrial Rectifier Equipment.

Rectifier Division
SEL-REX CORPORATION
NUTLEY 10, NEW JERSEY
Representatives in Principal Cities
"Complete Semiconductor Power Conversion Systems for any AC to DC application"

For more information, turn to Data Service card, circle No. 39

HOW TO SLEUTH OUT THE TRUTH ABOUT EXPANSION JOINTS

1 **Case the joint (design, that is)**

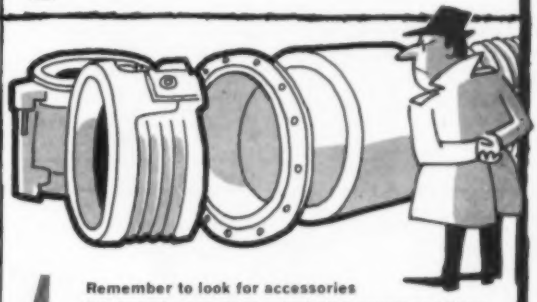
Badger S-R Expansion Joints have: 1. Corrugations which assume "all curve" shape under pressure — low stress, long life. 2. Tubular rings allow flexing over more of corrugation height.

2 **"Weigh" the evidence**

S-R Joints have no bulky castings . . . weigh up to 50% less . . . diameter equivalent to pipe flange. Installation is easier, lighter supports required.

3 **Search for clues in fabrication methods**

Bellows are hydraulically formed to produce uniform corrugations with minimum thinning of material. Quality controlled longitudinal welding, no multiple circumferential welds.



4 **Remember to look for accessories**

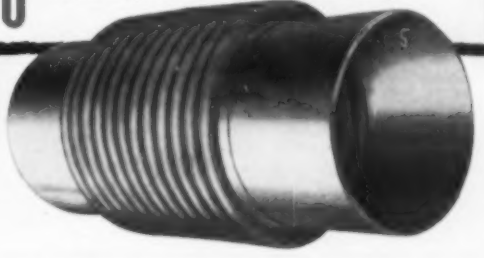
Full line of accessories — including covers and liners. Easy to pick proper combination of model, type and accessories for any pressure, temperature, erosive or corrosive condition.

5 **Pull an M.O. on the manufacturer's background**

Badger's 50-year experience includes development of first successful self-equalizing design for higher pressures, temperatures. Badger has had more fabrication and engineering experience in more different applications than any other manufacturer.

6 **Close the case — buzz Badger**

See the Badgerman for expert help on your most exacting pipe expansion problems. He knows his business, your problems. Call or write today.



BADGER *Expansion Joints* **S·R**

BADGER MANUFACTURING COMPANY
230 Bent Street, Cambridge 41, Mass.
Representatives in Principal Cities

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For more information, turn to Data Service card, circle No. 44

institutional news

21-and-Over Club new members

The super-salesmen of A.I.Ch.E. (L. to r., top) Abercrombie, Holcomb, Keller, Kunkel, Mayers, (bottom) Minden, Morrison, Scott, Sourelis. Not shown: Born, Wimmer and Sammond.

AN EVEN DOZEN top recruiters for A.I.Ch.E. have joined the special circle of members of the 21-and-Over Club. This club, established by *CEP* in 1957 and rapidly becoming a tradition, adds to its roster each year only those who bring in 21 or more new applications during the annual membership drive.

For 1959, the **South Texas Section** leads the list with a total of 71 new applications brought in by H. A. Holcomb. Closely following is **Philadelphia-Wilmington,** with D. E. Abercrombie bringing in 66 new applications. Other star go-getters who appear again this year, in addition to Abercrombie who topped the list last year, are Scott, Kunkel, and Morrison.

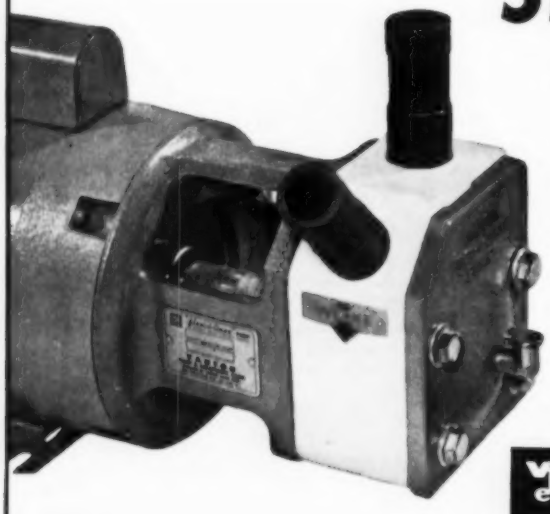
Other sections in the charmed circle by virtue of the work of the 21-and-Over Club members are:

Northern California	C. S. Minden	37
New York	J. H. Born L. C. Wimmer	36
Southern California	G. J. Keller J. M. Kunkel	36
Chicago	S. G. Sourelis	35
New Jersey	J. H. Sammond	30
Pittsburgh	J. W. Mayers	28
Sabine Area	J. W. Scott	25
St. Louis	H. B. Morrison	21

Total number of new applications for 1959 is 1837, a slight drop over the revised total of 1924 for 1958.

A live wire campaign to get new members is now in progress, inspired by the work done in last year's drive, particularly by these local section leaders. Plans mapped at the beginning of the year by the membership committee divide the country into six geographical regions: northeast, eastern, southeast, midwest, southwest, western.

The great contribution that A.I.Ch.E. is making to the chemical engineering profession, and to professional standards, can only continue if the organization grows constantly. The work of these new club members will be an inspiration to all of us. #



SEALLESS PLASTIC PUMPS

TO HANDLE CORROSIVES, ABRASIVE SLURRIES AND GASES . . .

Vanton self-priming, non-agitating, Flex-i-liner pumps have no troublesome shaft seals, stuffing boxes, gaskets or check valves; they do not leak or contaminate; have a longer pump life and require little maintenance under even the most exacting process applications.

There are plastic pump, body and liner combinations, e.g. Teflon, PVC, Neoprene, Viton A — 54 to be exact — to resist virtually all chemical corrosives and their combinations.

These unique and versatile pumps are designed to meet most process operation needs and are available in capacities from ⅓ to 40 GPM with discharge pressures to 60 PSI and with temperature range of from −60°F to +400°F. WRITE FOR FREE CATALOG AND SPECIFICATIONS INFORMATION.

Vanton PUMP & EQUIPMENT CORP.

DIVISION OF COOPER ALLOY CORP., HILLSIDE, N. J.

For more information, turn to Data Service card, circle No. 56

CREATIVE ENGINEERING
TRANSLATED INTO PRACTICAL PRODUCTION

SARGENT imaginative engineering has created numerous "firsts" that are now standard in many industries . . . better drying equipment and methods for better production and better products at less cost.

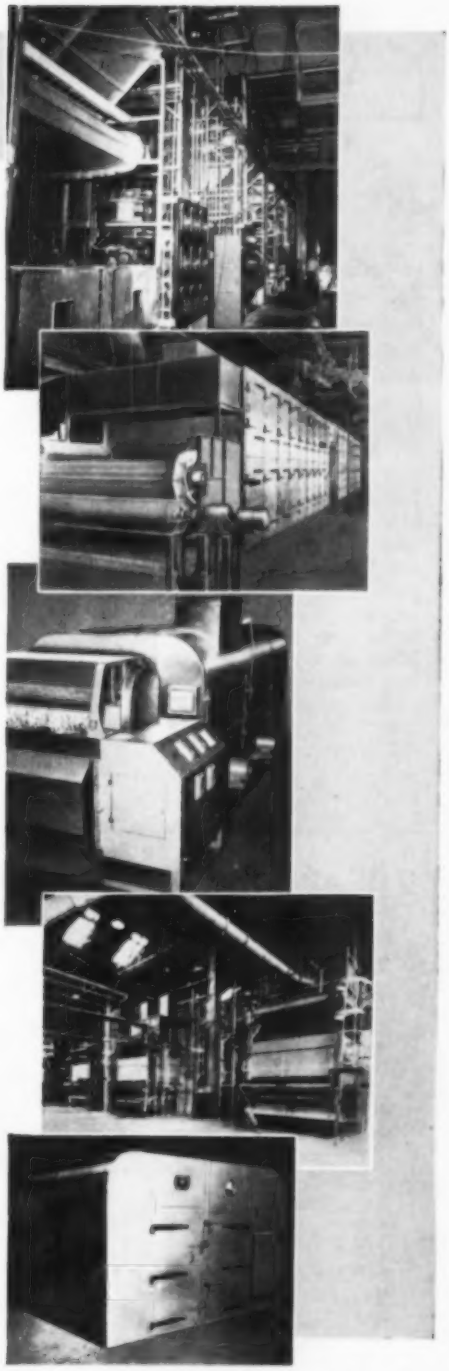
The first gas-fired rubber dryer was a Sargent. The first flashless powder was dried in a Sargent. The first gas-fired conveyor dryers for tobacco, for grain, for wool stock, all were Sargents. New man-made textile fibres and innumerable other products have come to the market dried by special-design Sargents that were designed, engineered and built to the exacting needs of product and of production.

From small lab and table models, from tray and truck dryers, through huge capacity, multi section, multi-stage conveyor dryers and rotary dryers, a Sargent is engineered to serve profitably and well for many years to come.

DRYERS
by SARGENT
Lead The Field

- in operating economy
- proven high-level production
- minimum of maintenance requirements
- easiest, quickest cleanout
- dependability of guaranteed performance
- fastest installation, with erection costs the lowest on the market

Let us give you details.



Sargent installations pictured above: Bank of 4 synthetic rubber dryers, 3-pass, gas-fired, at Goodyear Tire and Rubber Company, Houston, Texas • Two-stage Kaolin dryer with Sargent double-hopper extruder, at American Industrial Clays, Sandersville, Ga. • Pilot plant dryer with extruder and cooling sections. Remarkably compact and efficient. At a well-known chemical company • Four Sargent dryers for England's first general purpose (bulk) synthetic rubber plant. Built under Sargent license — installed at International Synthetic Rubber Co., Ltd., Hythe, Southampton • Two-compartment truck dryer with controlled even heat distribution through all trucks, at a large chemical company.

DRYERS (Conveyor, Tray, Truck, Rotary, Pole, Tunnel, Laboratory, Pilot Plant)
COOLERS • FEEDERS • EXTRUDERS • GRANULATORS

C. G. SARGENT'S SONS CORPORATION
Graniteville, SINCE 1852 Massachusetts

PHILADELPHIA • CINCINNATI • ATLANTA • CHARLOTTE • HOUSTON • CHICAGO • DETROIT • TORONTO

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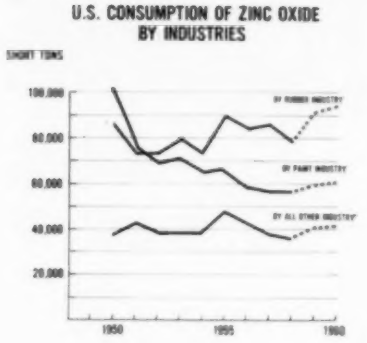
industrial news

Zinc oxide faces two-pronged market threat

Inroads by emulsion-type paints, declining percentages in rubber formulations, pose difficult sales problem.



A TOTAL U. S. PAINT consumption of 670 million gallons by 1965 is not unlikely, said R. H. Crossley of St. Joseph Lead, speaking at the Annual Meeting of the American Zinc Institute. However, all is not rosy in the zinc oxide sales picture. During the past decade, pointed out Crossley, an increasing gallonage of paint has been made with little or no zinc oxide. Much of this decline is attributed to re-formulation techniques: replacement of leaded zinc oxide with lead-free; replacement of linseed oil vehicles with synthetic resin types, with reduction or elimination of zinc oxide; and increasing use of emulsion paints containing no zinc oxide. From only a few gallons in 1950, Crossley predicts that emulsion paints will have captured nearly 14% of the total paint market by 1965, or about 94 million gallons. On an over-all basis, consumption of zinc oxide by the paint industry has shown a steady decline from 104,000 tons, or 45% of the total zinc oxide market in 1950, to about 60,000 tons, or 31% of the total in 1959.

Zinc in the rubber industry

Rubber consumption increased from 1,510,000 tons in 1950, to about 1,940,000 in 1959, and should reach between 2,100,000 and 2,200,000 tons by 1965, said Crossley. Consumption of zinc oxide in the rubber industry increased only from about 88,000 tons in 1950 to about 92,000 tons in 1959. Reason—in 1950, 5.8 pounds of zinc oxide were used for every 100 pounds of rubber; in 1959, the figure had dropped to 4.8, is expected to go lower.

Import threat

"Growing concern" was expressed by Crossley about a rapid increase of imports. From less than 200 tons of zinc oxide in 1952, he stated, imports reached 16,500 tons in 1959, are estimated at 19,000 tons in 1960.

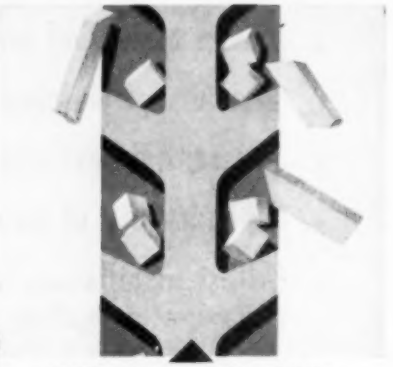
get accurate sizing with SIMON-CARTER machines

PRECISION GRADERS SEPARATE MATERIAL BY THICKNESS

For sizing and separating free-flowing granular materials by *thickness*, Carter Precision Graders use revolving cylinders with slotted perforations. Material placed in these cylinders is upedged and presented to the slots in an edgewise position. The thinner pieces pass through, and the thicker pieces pass over and are conveyed to the end of the machine.

CARTER GRADERS ALSO SIZE AND SEPARATE BY WIDTH

For *width* sizing and separating, the Precision Graders use revolving cylinders with round perforations. Material placed in these cylinders is upended and presented to the round perforations in an endwise position. Narrow pieces pass through, and wider pieces pass over for discharge at the end of the cylinder.



CARTER SEPARATORS ASSURE POSITIVE LENGTH SEPARATION

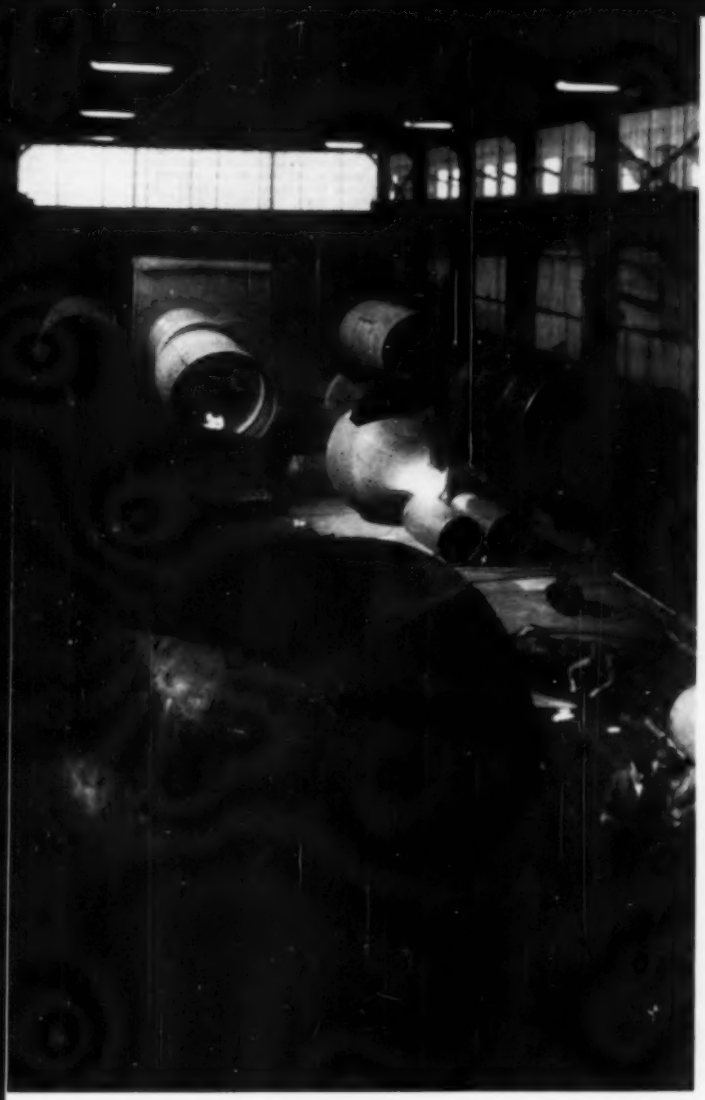
Carter Disc Separators contain a series of discs, each of which has hundreds of undercut pockets which select or reject materials according to *length*. As the discs revolve through a mixture of materials, the pockets lift out shorter pieces. Longer pieces, too long to be held in the pockets as they rise, drop away from the discs.

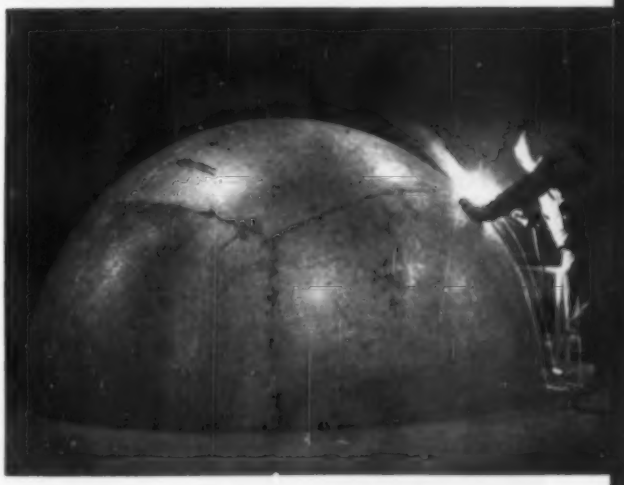
Write today for complete information and descriptive booklets on Simon-Carter machines. Free laboratory testing and demonstrating service.

SIMON-CARTER CO. 697 19TH AVENUE N.E. MINNEAPOLIS 18, MINNESOTA

For more information, turn to Data Service card, circle No. 74

For more information, circle No. 147 ➤





Graver's Experience Counts So Much When Cryogenic Storage Calls for Jacketed Stainless Steel Spheres

A practical and efficient method of storing liquid oxygen at customers' plants was found in 9 ft. double-shell spheres by the Linde Company (Div. of Union Carbide). Type 304 stainless steel was specified for the inner shell, carbon steel for the outer shell.

Keeping oxygen liquid at 297° below zero for prolonged periods required air-tight welding to assure holding a vacuum between the shells where a Linde-patented powder-vacuum insulation is employed.

Graver's quality fabrication and welding skills are called upon regularly to produce cryogenic storage and processing equipment. Graver's extensive knowledge of the field assures the most satisfactory type of equipment for efficient operation and long life.

Graver

DIVISION—UNION TANK CAR COMPANY

Graver Tank & Mfg. Co.

EAST CHICAGO, INDIANA

PLANTS AND OFFICES ACROSS AMERICA

Here's a complete ½" In-Line Valve with a 7.5 C_v! Springless (pneumatic or hydraulic), spring-to-open or spring-to-close operation. The operating method can be changed easily in the field without extra parts.

Write or call today for complete details on this extraordinarily compact In-Line Valve for on-off or control applications.

OTHER SIZES AND END CONNECTIONS AVAILABLE

GEORGE W.
DAHL
COMPANY, INC.
86 TUPELO STREET
BRISTOL, RHODE ISLAND
CLifford 3-9500

VALVES AND CONTROLS FOR THE COMMUNICATIONS, PROCESS AIRCRAFT AND MARINE INDUSTRIES

For more information, circle No. 58

future meetings

1960—MEETINGS—A.I.Ch.E.

• Mexico City, Mex., June 19-22, 1960. Hotel Del Prado. **Joint Meeting with Instituto Mexicano de Inginieros Quimicos.** See p. 132.

• Moscow, USSR, June, 1960. 1st Congress of International Fed., Automatic Control. To cover areas of **Theory, Hardware & Applications of Automatic Control,** U. S. participation sponsored by American Automatic Control Council. Affiliated societies: **A.I.Ch.E., ASME, AIEE, IRE, ISA.** A.I.Ch.E. Chmn.: D. M. Boyd, Universal Oil Prods., Des Plaines, Ill.

• Buffalo, N. Y., Aug. 14-17, 1960. Statler Hilton Hotel. **4th National Heat Transfer Conference & Exhibit. Sponsored by A.I.Ch.E. & ASME.** A.I.Ch.E. sponsored panel discussion on **Discrepancies Between Design Procedure & Plant Operation.** Moderated by D. Q. Kern. Panelists: D. J. Bergman, Union Oil; C. H. Brooks, Sun Oil; C. H. Gilmour, Union Carbide Chem.; A. C. Mueller, Dupont. A.I.Ch.E. papers to S. W. Churchill, U. of Mich., Ann Arbor, Mich. ASME papers to J. P. Hartnett, U. of Minnesota, Minneapolis, Minn. Exhibit info to P. A. Joculvar, A.I.Ch.E., 25 West 45 St., N. Y. 36, N. Y.

• Boston, Mass., Sept. 7-9, 1960. M.I.T. **Joint Automatic Control Conference.** Sponsored by A.I.Ch.E., AIEE, IRE, ASME, ISA. For A.I.Ch.E. info refer too: W. H. Abraham, Eng. Exp. Sta., Dupont, Wilmington 98, Del.

• Tulsa, Okla., Sept. 25-28, 1960. Hotel Mayo. **A.I.Ch.E. National Meeting.** Tech. Prog. Chmn.: K. H. Hachmuth, Phillips Petroleum Co., Bartlesville, Okla. **Multiphase Flow in the Production & Drilling of Oil Wells**—L. P. Whorton, Atlantic Refining, Box 2819, Dallas 1, Texas. **Natural Gas & Natural Gas Liquids**—R. L. Huntington, U. of Oklahoma, Norman, Okla. **Advances in Refinery Technology**—W. C. Offutt, Gulf R&D Co., P. O. Drawer 2038, Pittsburgh 30, Pa. **Petrochemicals**—C. V. Foster, Continental Oil Co., Ponca City, Okla. & H. L. Hays, Phillips Chem. Co., Bartlesville, Okla. **Piloting or Why Buy the Restaurant When All You Need is a Meal**—R. E. Weis, Phillips Pet. Co., Bartlesville, Okla. & D. Popovac, Continental Oil Co., Ponca City, Okla. **Corrosion & Materials of Construction**—W. A. Luce, The Duriron Co., P.O. Box 1019, Dayton 1, O., & M. S. Whorley, Black, Sivalls & Bryson, P.O. Box 1714, Oklahoma City, Okla. **Statistics and Numerical Methods Applied to Engineering**—R. L. Heiny, 2709 Jefferson, Midland, Mich. **Air & Ammonia Plant Safety**—G. Weigers, Amer. Cyanamid Co., P. O. Box 10008, Jefferson Branch, New Orleans 21, La. **Refinery & Natural Gasoline Plant Safety**—J. N. Romine, Phillips Petrol., Bartlesville, Okla. **Processing Agricultural Products**—A. Rose, Tex. Eng. Exp. Sta., Tex. A&M, Coll. Sta., Tex. **Chemical Reactions Induced or Modified by Radiation**—J. J. Martin, Ch.E. Dept., U. of Mich., Ann Arbor, Mich. **Conservation & Utilization of Water**—F. J. Lockhart, Ch.E. Dept. of U. of So. Cal., 3551 University Ave., Los Angeles 7, Cal. **Foams**—C. S. Grove, Jr., Syracuse U., Syracuse 10, N. Y. & R. L. Tuve, U.S. Naval Rsch. Lab., Wash. 25, D.C. **Computers as a Management Tool**—R. Cziner, Grace Chem. Co., 3 Hanover Square, New York 4, N. Y. **Non-Newtonian Fluid Mechanics**—A. B. Metzner, U. of Delaware, Newark, Del. **Student Program**—O. K. Crosser, Univ. of Oklahoma, Norman, Okla. **Selected Papers**—R. H. Perry, Ch.E. Dept. U. of Oklahoma, Norman, Okla.

• Washington, D.C., Dec. 4-7, 1960. Statler Hotel. **A.I.Ch.E. Annual Meeting.** Tech. Prog. Chmn.: D. O. Myatt, Science Communication, Inc., 1079 Wisconsin Ave., N.W., Wash. 7, D.C. **Air Pollution**—A. J. Teller, U. of Florida, Gainesville, Fla. **Unsteady-State Instrumentation**—T. J. Williams, Monsanto Chem. Co., St. Louis, Mo. **Fluid Dynamics**—A. C. Acrivos, U. of California, Berkeley, Calif. **Information & Communications**—R. O'Dette, NSF, Wash., D. C. **Nuclear Reactor Operations**—R. L. Cummings, Atomics International, Canoga Park, Calif. **Nuclear Chemical Plant Safety**—C. E. Dryden, Ohio State U., Columbus, O. **Phase Transitions**—G. Bankoff, Northwestern U., Evanston, Ill. **Sales Overseas**—J. Costigan, The Sharpless Corp., 501 Fifth Ave., New York 17, N.Y. **Chemical Engineering—A Vital Link in Broadening the Uses of Agriculture Crops**—J. E. Simpson, U.S.D.A. **Chemical Warfare-Dispersal of Materials in Aerosol Form**—L. E.

continued on next page

"DELANIUM" GRAPHITE BURST DISCS... FOR RELIABLE LOW-COST PERFORMANCE

After 30,000 cycles at 75% of rated pressure, "Delanium" high-density graphite discs will still fail within the ±5% ASME burst tolerance!

Low-cost, replaceable discs are easily installed in re-usable carbon or aluminum holders. Ratings and sizes stamped on external "ears" are plainly visible, even when installed.

Immediate delivery from stock on standard sizes: 1" to 8"; burst pressure ratings 1 to 400 psig; operating temperatures to 650° F. Other sizes and ratings to order. Write for technical data and price schedule.

KEARNEY INDUSTRIES
DELANIUM GRAPHITE DIVISION
P. O. BOX 501 SOUTH PLAINFIELD, N. J.

For more information, turn to Data Service card, circle No. 84

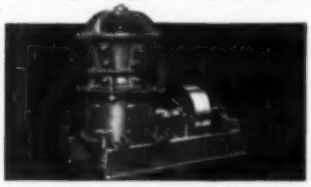
NO MAJOR REPAIRS IN 25 YEARS*

Sturtevant Construction Assures Long Mill Life at Top Loads

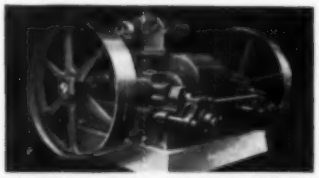
Sturtevant crushing and grinding machinery answers the long life top-load production problem for medium to small size plants. Many Sturtevants have been operating above rated capacities for more than 25 years, and *without a major repair.*

"Open-Door" design gives instant accessibility where needed — makes cleanouts, inspection and maintenance fast and easy. Machines may be set up in units to operate at equal quality and capacity.

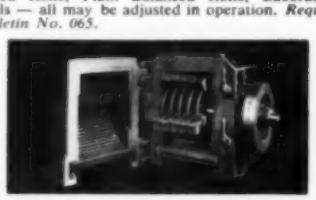
Jaw Crushers — Produce coarse (5 in. largest model) to fine (⅛ in. smallest model). Eight models range from 2 x 6 in. jaw opening (lab model) to 12 x 26 in. Capacities to 30 tph. All except two smallest sizes operate on double cam principle — crush double per energy unit. *Request Bulletin No. 062.*



Rotary Fine Crusher — Reduce soft to medium hard 3 to 8 in. material down to ¼ to 1¼ in. sizes. Capacities up to 30 tph. Smallest model has 6 x 18 in. hopper opening; largest, 10 x 30 in. Non-clogging operation. Single handwheel regulates size. *Request Bulletin No. 063.*



Crushing Rolls — Reduce soft to hard 2 in. and smaller materials to from 12 to 20 mesh with minimum fines. Eight sizes, with rolls from 8 x 5 in. to 38 x 20 in.; rates to 87 tph. Three types — Balanced Rolls; Plain Balanced Rolls; Laboratory Rolls — all may be adjusted in operation. *Request Bulletin No. 065.*



Hammer Mills — Reduce to 20 mesh. Swing-Sledge Mills crush or shred medium hard material up to 70 tph. Hinged-Hammer Pulverizers crush or shred softer material at rates up to 30 tph. Four Swing-Sledge Mills with feed openings from 6 x 5 in. to 20 x 30½ in. Four Hinged-Hammer Pulverizers with feed openings from 12 x 12 in. to 12½ x 24 in. *Request Bulletin No. 084.*

**Reports Manager W. Carleton Merrill concerning Sturtevant Swing-Sledge Mill at James F. Morse Co., Boston.*

STURTEVANT
MILL COMPANY
135 Clayton Street, Boston 22, Mass.

For more information, circle No. 8

Future meetings

continued

Garono, Army Chem. Corps. **Role of the Chemical Engineer in Environmental Health Engineering**—W. L. Faith, Air Pollution Foundation, 2556 Mission St., San Marino, Calif. **Feeding, Clothing, and Protecting the Combat Soldier**—Leo Spano, Quartermaster R&Eng. Command, Natick, Mass. **Phenomena Affecting Materials in Extreme Environments**—J. Hearne, Air Force R&Eng. **Impact of Govt. Programs on Chemical Engineering Education**—W. K. Davis, Bechtel Corp. **Toxic Plant Construction**—L. E. Garono, Army Chem. Corps. **Potentialities of Fuel Cells as Power Sources**—P. Greer, Army OOR. **Saline Water Conversions**—J. J. Strobel, OSW, Dept. Int. **Chemical Engineering in the Mineral Industry**—H. Perry, Chf. Bit. Coal Res. Br., U.S. BuMines. **Rocket Propellants**—W. E. Sheehan, DDRE. **Economic Evaluation of New Processes**—J. H. Hirsch, Gulf R&D Co., P.O. Drawer 2038, Pittsburgh 30, Pa. **New Crystallization Techniques**—H. M. Schoen, American Cyanamid Co., 1937 W. Main St., Stamford, Conn. **Heat Transfer**, Papers requested—M. Altman, Gen. Elec. Co., 3198 Chestnut St., Philadelphia, Pa.

Deadline for papers: July 5, 1960.

1961—MEETINGS—A.I.Ch.E.

• New Orleans, La., Feb. 26-March 1, 1961. Hotel Roosevelt. **A.I.Ch.E. National Meeting.** Tech. Prog. Chmn.: A. L. Resnler, Petroleum Chem., P.O. Box 6, New Orleans 6, La. **Brainstorming Technical Problems**—G. C. Szego, Space Technology Labs., P.O. Box 95001, Los Angeles 45, Calif. **Kinetics of Catalytic Reactions**—M. Boudart, Princeton U., Princeton, N.J. **Petrochemicals—Future of the Industry on the Gulf Coast**—J. A. Sherred, Monsanto Chem. Co., St. Louis 66, Mo. **Filtration**—P. M. Tiller, U. of Houston, Houston, Texas. **Settling**—A. G. Keller, La. State U., Baton Rouge, La. **Future Processing Technology in the Petroleum Industry**—A. P. Kaulakis, Process Res. Div., ESSO. **Education and Professionalism**—R. P. Dinsmore, Goodyear Tire & Rubber Co., Akron 16, O. **Mathematics in Chemical Engineering**—R. L. McIntire, Mathematical Eng. Assoc., 3108 Sweetbriar, Fort Worth 9, Tex. **Evaluation of R&D Projects**—L. A. Nicolai, 239 Parsonage Hill Rd., Short Hills, N.J. **Liquid—Liquid Extraction**—R. B. Beckman, Carnegie Tech., Pittsburgh 13, Pa. **New Petrochemical Processes in the Area**—B. G. Caldwell, Dow Chem. Co., Plaquemine, La. **Materials of Construction**—R. V. Jelinek, Syracuse U., Syracuse, N.Y. **Thermodynamics** J. J. Martin, Ch.E. Dept., Univ. Calif., L.A. 24, Calif. **Use of Probability Mathematics in Economic Evaluation**—A. G. Bates, Atlas Powder Co., New Murphy Rd., Wilmington 99, Del. **Selected Papers**—E. Mannings, Shell Oil Co., Norco, La.

Deadline for papers: Sept. 5, 1960.

• Cleveland, O., May 7-10, 1961. Hotel Sheraton, Cleveland. **Joint A.I.Ch.E. National Meeting with Ch.E.Div. C.I.C.** Tech. Prog. Chmn.: R. P. Dinsmore, Goodyear Tire & Rubber Co., Akron 16, O. **Petrochemicals as Starting Materials for Polymers**—L. F. Marek, A. D. Little, 30 Memorial Dr., Cambridge 42, Mass. **Fluid Mechanics**—W. H. Gauvin, McGill Univ., Montreal, Que. **Optimum Utilization of Pilot Plants**—J. T. Cumming, School Eng., Penn College, Cleveland 15, O. **Process Dynamics (Theoretical)**—R. M. Butler, Imperial Oil Co., Sarnia, Ont. **Synthesis Processes for Isoprene**—T. A. Burtis, Houdry Process Corp., 1528 Walnut St., Phila. 2, Pa. **Radioactive Materials for Process Control**—J. R. Bradford, College of Eng., Texas Tech. College, Lubbock, Tex. **Process Dynamics (Applied)**—L. M. Naphtali, Ch.E. Dept., Brooklyn Polytech., Brooklyn, N. Y. **New Synthetic Rubber Types**—P. M. Lindstedt, Goodyear Tire & Rubber Co., Ch.E.Div., Akron 16, O. **Coalescence**—R. Kintner, Illinois Inst. Tech., Chicago 16, Ill. **Management Criteria for Capital Investment**—C. F. Prutton, Food Machy. & Chem. Co., 161 E 42d St., New York 17, N. Y. **Ch.E. in Metal Refining**—W. M. Campbell, Chem. & Met. Div., Atomic Energy of Can., Chalk River, Ont. **Heavy Metal Mfr.**—L. P. Scoville, Diamond Alkali, Union Commerce Bldg., Cleveland 14, O. **Applications of High Speed Photography**—A. I. Johnson, Univ. Toronto, Toronto 5, Ont. **General Papers**—D. J. Porter, Diamond Alkali, P. O. Box 348, Rsch Center, Painsville, O. **Student Program**—H. B. Kendall, Case Inst., 10900 Euclid Ave., Cleveland, O.

Deadline for papers: Dec. 7, 1960.

continued on page 152

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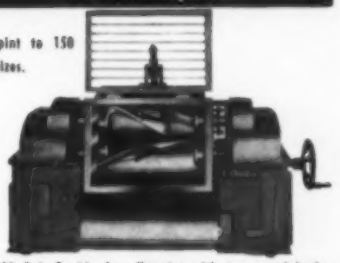

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Future meetings

from page 151

• Lake Placid, N. Y., Sept. 24-27, 1961. Lake Placid Club. **A.I.Ch.E. National Meeting.** Tech. Prog. Chmn.: E. R. Smoley, 30 School Lane, Scarsdale, N. Y. **Process Management; Commercial Chemical Development; Sales Engineering.**

• New York, N. Y., Dec. 3-6, 1961. Hotel New Yorker. **A.I.Ch.E. Annual Meeting.** Tech. Prog. Chmn.: A. V. Caselli, Shell Chem. Corp., 50 W. 50 St., N. Y. 20, N. Y. **Heat Transfer; Management; New Processes; Nuclear Engineering; Water Pollution; Process Dynamics; Pilot Plants; Fundamentals; Petroleum & Petrochemicals; Fluids; Fluidization; Sublimation; Adsorption; Student Program.**

Unscheduled Symposia

Correspondence on proposed papers is invited. Address communications to the Program Chairman listed with each symposium below.

Computers in Optimum Design of Process Equipment: Chen-Jung Huang, Dept. of Chem. Eng., Univ. of Houston, Cullen Blvd., Houston 4, Texas.

Solar Energy Research: J. A. Duffie, Director of Solar Eenrgy Laboratory, Univ. of Wisconsin, Madison, Wis.

Hydrometallurgy—Chemistry of Solvent Extraction: G. H. Beyer, Dept. of Chem. Eng., Univ. Mo., Columbia, Mo.

Process Dynamics as They Affect Automatic Control—D. M. Boyd, Universal Oil Prods., Des Plaines, Ill.

Drying—R. E. Peck, Ill. Inst. of Tech., 330 So. Federal, Chicago, Ill.

Author Information

Procedure in submitting papers.

1. Obtain five copies of "Proposal to present a paper before the A.I.Ch.E.," plus one copy of "Guide to Authors" from Secretary, A.I.Ch.E., 25 West 45th St., New York 36, N. Y.

2. Send one copy of completed form to Technical Program Chairman for meeting selected from above list.

3. Send another copy to Norman Morash, Titanium Div., Natl. Lead Co., P. O. Box 58, So. Amboy, N. J. (Chmn. Program Comm.)

4. Send third copy to Editor, Chemical Engineering Progress, 25 West 45th St., New York 36, N. Y. Paper will automatically be considered for possible publication in A.I.Ch.E. Journal.

5. If desired to present paper in a selected symposium send fourth and fifth copies to chairman of the symposium.

6. Prepare six copies of manuscript. Send one copy to Symposium chairman or the Selected Papers chairman, whichever is appropriate.

7. Send one copy to Joel Henry, Ass't. Secretary, A.I.Ch.E., 25 West 45th St., New York 36, N. Y.

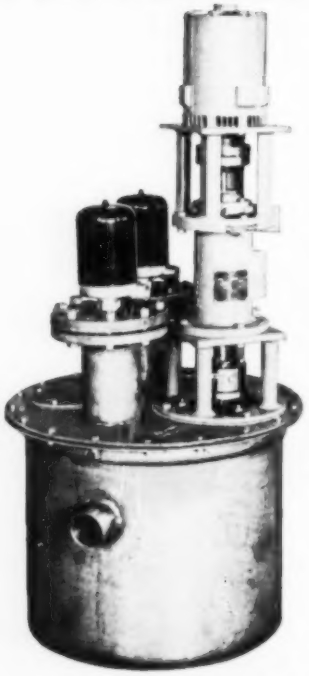
8. Send one copy to Technical Program Chairman.

9. Send three copies to A.I.Ch.E. Manuscript Center, 25 West 45th St., New York 36, N. Y.

How Come You Didn't know About—

The Petrochemical and Refining Exposition to be held in conjunction with the National A.I.Ch.E. Meeting in New Orleans, Feb. 26-Mar. 1, 1961? The theme will be the Chemical Engineer's role in design and development of petroleum and petrochemical facilities.

Nagle Pumps for the Atomic Age



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industrial news

Fertilizer sales picture bright

Boom to continue this year, says IMC president—but future depends on Congress.

PLANT NUTRIENT CONSUMPTION jumped to record heights for the year ending June 30, 1959, to a whopping 13.6% over 1958, according to T. M. Ware, president of International Minerals & Chemicals. Ware's report was presented at a recent IMC Customer Advisory Panel in Chicago.

Mixed fertilizer consumption went up to a new high—10.9%, or about 1.5 million tons over 1957-1958. However, since mixed fertilizer has become more concentrated—30.2 units per ton in 1959 compared to 23.1 units in 1950—consumption of plant nutrients for 1958-1959 was up 13.4% over the previous year, or more than double the average change (5.5% between 1950 and 1958).

Potash, phosphates climb

Potash consumption, with an average yearly rate of 7.2% between 1950 and 1958, chalked up an increase of 12.5% last year. Triple superphosphate, on the other hand, rose only 8.9%, not up to the eight-year annual average of 11.1%. Decline in triple is attributed by Ware to limited supply and displacement by other phosphate products, particularly phosphoric acid. Shipments of Florida phosphate rock for the domestic market last year, however, were up by 12.8% over 1957-1958, an increase of more than a million tons. Even normal superphosphate, steadily replaced by triple over the past few years, showed an increase of 5.7% over the previous year.

Contributing factors

Relaxed production restrictions by the Department of Agriculture, according to Ware, made possible an increase of 11 million acres in corn and 3.3 million acres in cotton. The two products together account for about 43% of total U.S. fertilizer application. Secondly, farmers had a two billion dollar increase in cash receipts in the 1957-1958 crop year, and three receipts added purchasing power last year.

For this year, predicts Ware, "fertilizer consumption will at least equal last year's record-breaking pace." #

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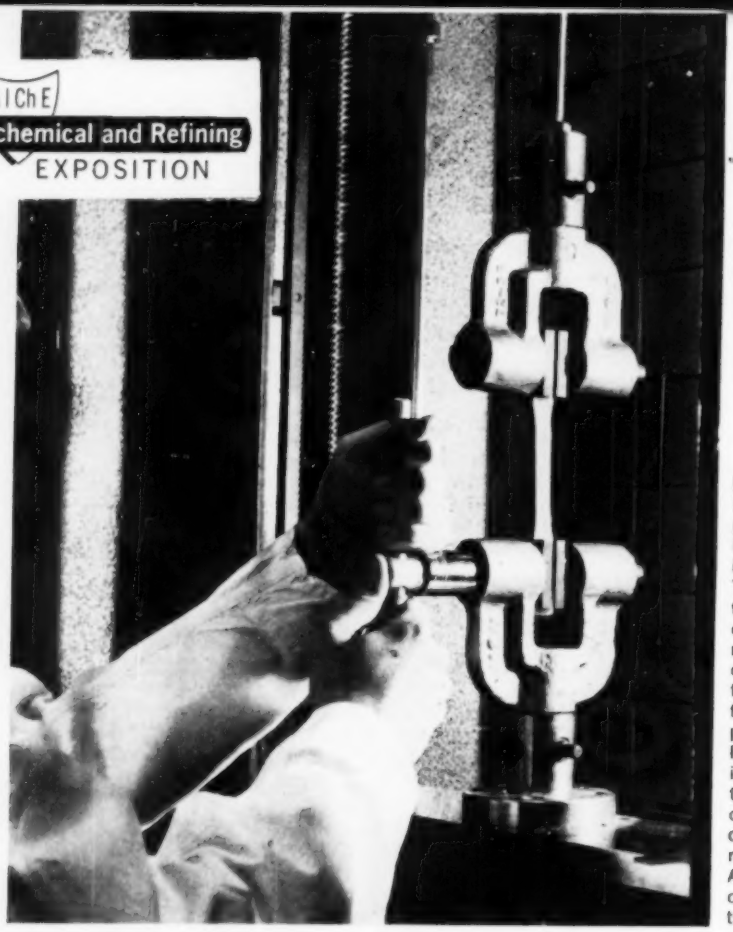
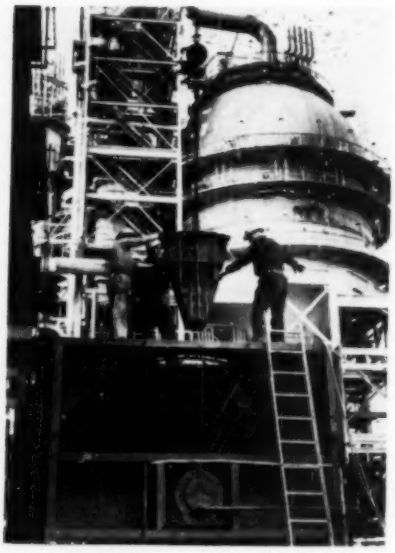


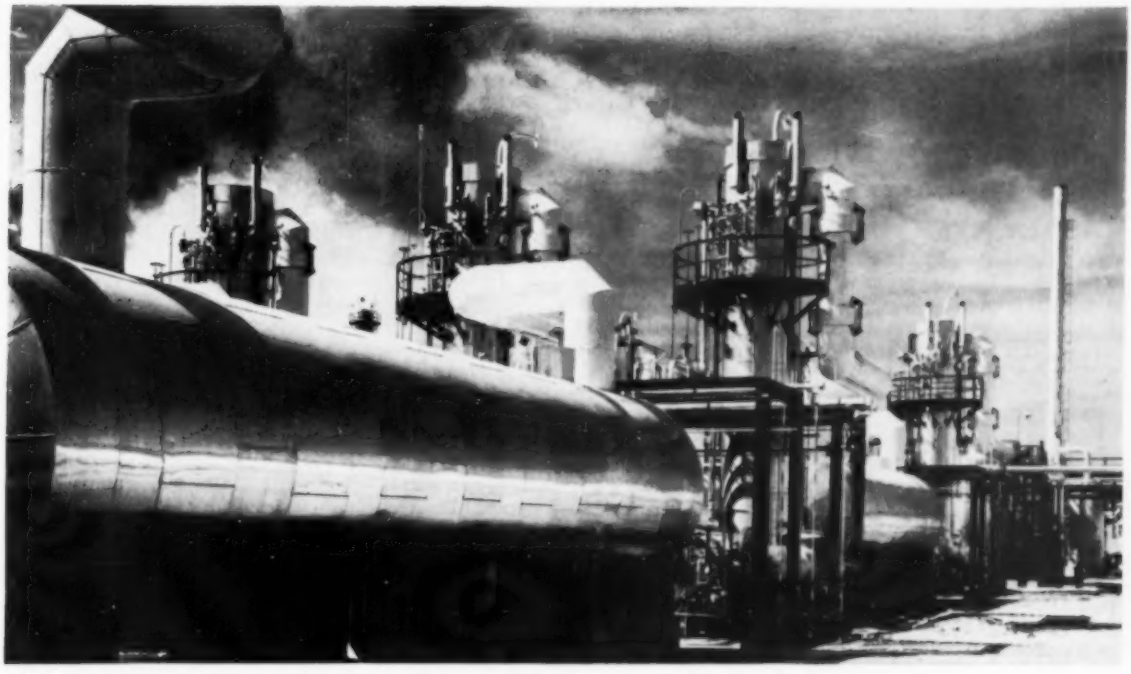
POLYPROPYLENE, here undergoing a tensile test, is now being produced at Humble Oil's 40 million lb. per yr. plant formally dedicated this month at Baytown, Texas. The output can be raised to a 100 million lb. rate with increased demand, and is being marketed by Enjay Co. and Spencer Chemical. This marks the first direct entry into the plastics field of Standard Oil Co. (N.J.), parent of Humble and Enjay. Polypropylene capacity has been increasing at a leapfrog pace, typical of the booming petrochemical industry which will be on parade in New Orleans, February 26-March 1, 1961, when A.I.Ch.E. presents the first Petrochemical and Refining Exposition.

"EVERY PHASE OF construction of the United Engineering Center is on schedule or a bit ahead," report from the site where (left) the basement floor is already being poured.



A NEW FURNACE equipped with a Ljungstrom air preheater has been installed at Esso Standard's (Humble) Bayway Refinery.

cep camera



A ONE-THOUSAND TON sulfur recovery unit just built at the gas processing plant of SNPA, Lacq, France. Design, engineering, procurement, and construction supervision were handled by The Ralph M. Parsons Co. of Los Angeles in collaboration with S.A. Heurtey Co., Paris. When joined by a twin unit, this will be the largest installation of its kind.

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President

Secretary

THE INSTITUTE SALUTES John Godfrey Dean of Anaheim, California, who has been a member of A.I.Ch.E. since October, 1908, a continuous span of more than fifty years service to the chemical engineering profession. Mr. Godfrey, now eighty-three years of age, was born in 1877 at Parma, Michigan, attended Albion College in Albion, Michigan.

people
in management
and technology

Holbrook named to post in EJC; Billing honored by CCDA

George E. Holbrook, past president of A.I.Ch.E. and a vice president of Du Pont, has been elected vice president of the Engineers Joint Council. Holbrook, who is also a director and executive committee member of Du Pont, has been with the Wilmington, Delaware, firm since 1933, with the exception of a brief period of service with the Chemical Division, National Production Authority in 1952. He held many posts at Du Pont, until his election to his present position in 1958. He is also a director of Du Pont Company (United Kingdom) Ltd., London, and Du Pont of Canada.

A graduate of the University of Michigan, Holbrook also received an MS and PhD from the same University. He was president of A.I.Ch.E. in 1958, vice president in 1957, and held the position of director in 1950-52. He has served on the board of directors of EJC. Holbrook is also a member of ACS, American Physical Society, Society of the Chemical Industry, and New York Academy of Science.

The essential element in the commercial chemical development picture is people, **Wyly M. Billing** told the Commercial Chemical Development Association Award Banquet. More than 500 were present when the Hercules Powder vice president received the 1960 Honor Award of the CCDA. Trained and enthusiastic people have not only carried out and improved upon his own ideas and efforts, Billing said, but have supplemented them with their own original thinking and methods. It is to these, the people of Hercules, particularly the commercial chemical developers, that this honor belongs, he added. The essential element that is needed at every stage, from conception to success, is the right kind of people, enthusiastic, dedicated, knowledgeable, cooperative people working together under inspired leadership as one cohesive unit. This ability to work closely together on all the separate aspects or details in the hands of the many groups was the key to success.

Billing was selected to receive the Award in recognition of his pioneering efforts in the field of commercial development; a career devoted to the application of its principles leading to the development, establishment and growth of Hercules' Synthetic Department; and for his inspiration, gui-

continued on next page

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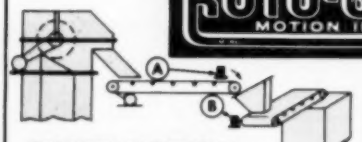

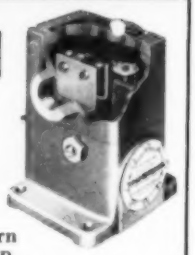

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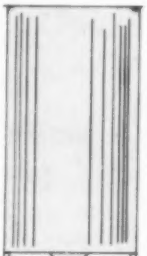

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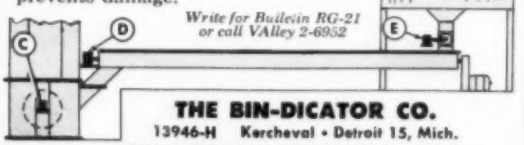

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people

continued

dance, and development of younger men in the field.

Chester P. Baker, chairman of the Department of Chemical Engineering at Northeastern University, was honored by students, faculty and alumnae at a testimonial dinner held recently at the college. A member of the Northeastern chemical engineering faculty for forty years, Baker is also a graduate of the college School of Engineering.

Keynote address at the ceremonies was given by University President, Asa S. Knowles. Baker was presented with a mahogany and bronze engraved plaque by the student chapter of A.I.Ch.E. Other greetings were extended by: Chancellor Carl S. Ell, William T. Alexander, Dean of the college of engineering, and university provost, William C. White. Baker's classmates from the School of Engineering, 1920, were represented by George A. Mallion, assistant dean of Lincoln Institute.

A consultant to the paper, paint and drug industries, Baker is author of several publications, both in the field of education and chemical engineering.

Donald O. McCarthy has been named assistant production manager for Petrothene polyethylene resins by U.S. Industrial Chemicals (National Distillers). McCarthy joined U.S.I. in 1956 as a technologist at the company's Tuscola, Illinois, plant.

Walter K. Stromquist has been appointed chief of plant systems engineering at Alco Products, Nuclear Power Engineering Department. He will handle component design and instrumentation for both primary and secondary systems. Before joining the Schenectady, N. Y., firm, Stromquist was with Westinghouse Electric.

Allen N. DeFriece and **William Chalpin** have joined Sun Oil's staff, the former in the Research and Engineering Administration, Chalpin in the Engineering Division.

W. D. Seyfried has assumed the newly created post of manager of research, Humble Oil & Refining. A 22-year veteran with the company, Seyfried was most recently head of the Baytown Refinery's Research and Development Division.

continued on page 158

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People

from page 157

Edward J. Massaglia has been elected to the board of directors of Atlas Powder. He is vice president and general manager of the company's Chemicals Division.

Frank Carvell is the new general manager for rocket motors of the Aviation Products Division, B F. Goodrich, Rialto, California. Carvell, who joined Goodrich in 1940, was production manager at the company development center at Avon Lake, Ohio, for fourteen years. Until his recent transfer to California, he was chairman of the Cleveland Section of A.I.Ch.E.

Ronald G. Macdonald has been promoted to the post of treasurer and editorial director at the TAPPI headquarters. An officer of the Association since 1928, Macdonald was formerly assistant to the president.

Charles Edward Leyes has joined Sonneborn Chemical and Refining as director of Building Products Laboratories. He comes to the company from Celanese Corp. where he was assistant to the technical director, Plastics Division. A former adjunct professor in the Management Engineering Department, Newark College of Engineering, Leyes is also a contributor to the *Encyclopedia of Chemical Technology*.

Morris E. Packman, Jr., will take over responsibility for coordination of research and development activities at Allied Chemical's National Aniline Division. He is technical assistant in the chemical areas of the division.

Fred C. Hands takes over as director of procurement for Goodrich-Gulf Chemicals. Previously manager of the company's synthetic rubber plant in Institute, West Virginia, he came to Goodrich-Gulf in 1956. In his new position Hands is on the president's corporate staff.

Robert J. Fanning has been promoted to research group leader, automation group, Continental Oil's Research and Development Department.

Raymond C. Ewell has been elected national chairman of the National Council of University Research Administrators, newly formed organization composed of top research executives of universities. Ewell is vice-chancellor for research at the University of Buffalo.

Truman S. Storvick has passed the required examination of the Missouri State Board of Registration for Architects and Engineers, and has qualified for registration as a professional engineer in the state of Missouri. Storvick is assistant professor on the chemical engineering faculty, University of Missouri College of Engineering.

Joe C. Dickson has joined Bonner & Moore Engineering Associates. He comes to the Texas consulting firm from Humble Oil & Refining where he worked in Lubes Processing and crude distillation.

Ralph Carlisle Smith has been named director, plans and programs, Lytle Corp. Smith has served as patent examiner for the U S. Patent Office. He spent fourteen years at the Los Alamos

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Scientific Laboratory, where he took part in all nuclear weapons tests in Nevada, the Pacific, and New Mexico

A. R. Webber has been named manager, production and technical operations, B.F. Goodrich Chemical vinyl resin and compound plant now under construction near Long Beach, California. Webber, with the company since 1946, was most recently senior engineer-economic planning.

Clifford E. Oman moves up at U.S. Industrial Chemical (National Distillers). He takes over the post of assistant to the director of production. Oman has been at the Tuscola plant of the company, most recently as general manager, since 1951 when he joined the staff as an area superintendent.

H. E. Lumpkin has been promoted to senior research chemist, and **H. E. von Rosenberg** to senior research chemical engineer at Humble Oil & Refining. They are in the Research and Development Division, Baytown, Texas.

New appointment at the Whiting research Laboratories, Standard Oil (Indiana) is **Robert L. Stack.** He is group leader, automotive-research division.

Andrew J. Chase and **John F. Gorman,** resident instructors at the University of Maine, will be members of the staff for the Summer Institute for the Pulp and Paper Industry. This will be held at the State University during July and August, at Orono, Maine. Chase is associate professor of chemical engineering, Gorham is assistant professor.

Smith served as co-editor of AEC's *Effects of Atomic Weapons,* and the National Nuclear Energy Series, published by McGraw-Hill.

David L. Eynon, Jr., was elected chairman of the board of the newly formed Sinclair-Koppers Chemical Co., and **John A. Scott** was named president. **C. W. Hardell** is vice president.

John Keselik has been advanced to the post of manager, Dow Chemical's Riverside plant at Pevely, Missouri. He was production superintendent there for five years. **Robert E. Reinker**

continued on page 160

The LEHMANN CAN CODING MACHINE

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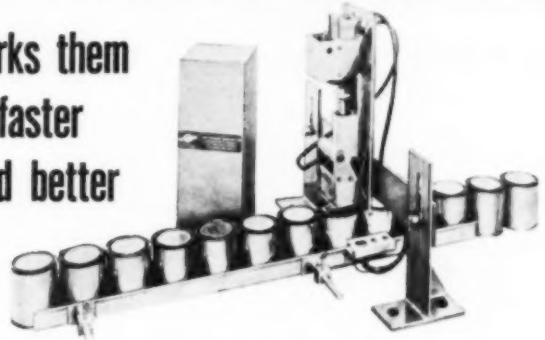

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For more information, circle No. 10

People

from page 159

leaves the managerial post to become assistant to the operations vice president, Dow Chemical International. His headquarters are at Midland, Michigan.

Alan S. Foust heads a team of authors, all from the chemical engineering faculty of Lehigh University, who have completed a book on *Principles of Unit Operations*. The book was written by three members and two former members of the Lehigh staff. Foust is head of the Department of Chemical Engineering at the college, **Leonard A. Wenzel** is associate professor, and **Curtis W. Clump** is assistant professor. **Louis Maus** is now with Cherokee Laboratories, while **L. Bryce Anderson** is associate professor of chemical engineering at Rice Institute.

Marketing

Douglas A. Rogers has been appointed to the position of manager, Process Equipment Division, Rodney Hunt Machine Co. He will direct sales activities, product development and laboratory testing for the Orange, Mass. firm.

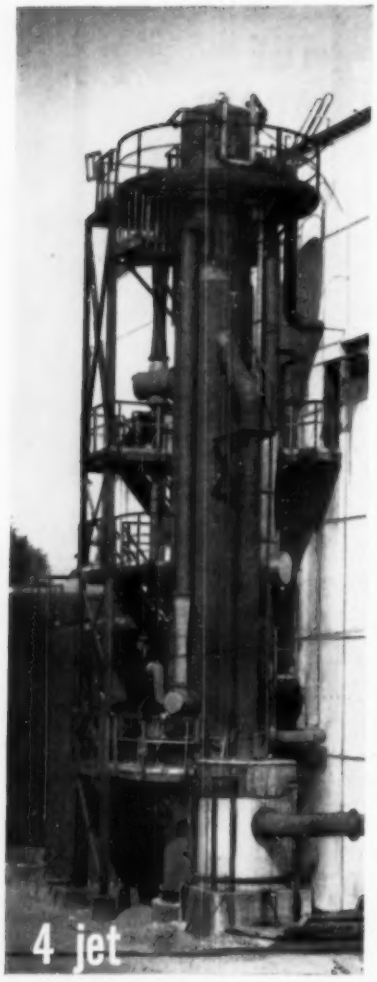
Robert M. Stroman has been promoted to manager, Buffalo sales district, Durez Plastics Division Hooker Chemical. Stroman has been with Durex since 1946, working mostly in the Buffalo area.

Mike Baker, president of the m.h. Baker Co., has been elected chairman of the Minnesota Section, ACS, for 1960. He is currently vice chairman of the Twin Cities Chapter of A.I.Ch.E. and chairman-elect for 1960. Baker also is a member of the board of the Minnesota Federation of Engineering Societies.

Richard M. Sibley has joined the international sales office of Dorr-Oliver. He will handle sales of D-O products in Venezuela and the Caribbean.

Max Potash has left on an extended trip to Europe to study the potential of the European polymer emulsion

Robert O. Ness has been assigned to General Mills' Chemical Division Kankakee district office. As sales representative for the division, he will handle sales in the Iowa and North Illinois area. Ness, who joined the company in 1954, had served as derivatives supervisor and senior process engineer.



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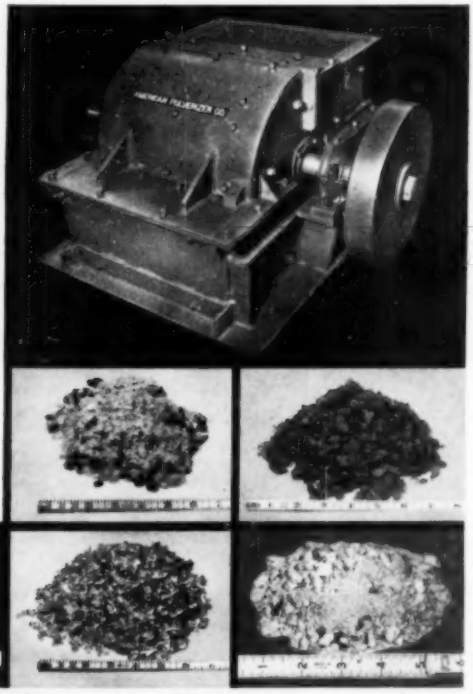

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market. Potash, president of Polyvinyl Chemicals, will visit over 50 European chemical specialty manufacturers, floor wax formulators, paper, leather and textile finishers, who are current customers of the company.

J. A. Sudduth has been appointed manager, St. Louis district, Allis-Chalmers. He moves from the Grand Rapids district to his new post in the St. Louis, Mo. office.

Norman L. Greenman has been elected vice president, marketing, Rogers Corp. He joined the Connecticut firm in 1948 as development engineer, and rose to director of marketing, a post he held till recently.

Necrology

Francis J. Curtis, recently retired vice president of Monsanto Chemical Co. A 45 year veteran with the company, he had been a member of the Board of Directors since 1949, and held the vice president's post since 1943. At the time of this retirement, Curtis was coordinator of personnel relations and secretary of the executive and finance committee. He was president of A.I.Ch.E. in 1949. Last year, Curtis received the A.I.Ch.E. Founders Award for his outstanding contributions to commercial chemical development in America. Also active in other professional societies, he was elected president of the Society of the Chemical Industry in 1952, at Aberdeen, Scotland.

Kenneth A. Spencer, 58, chairman of the board and founder of Spencer Chemical Co. He was also president of the Pittsburgh and Midway Coal Mining Co. It was this company, along with the subsidiary Military Chemical Works, that was merged into the Spencer Chemical Company in 1946. Spencer was a founder of the Midwest Research Institute and a member of the board of several leading firms.

Frank C. Vilbrandt, 67, retired professor of chemical engineering at Virginia Polytechnic Institute. He had taught at VPI since 1935, and until his recent retirement. Vilbrandt also held posts at the University of North Carolina, Iowa State College and Ohio State. During World War II, he worked on the Manhattan project, and had also held various advisory positions with the U.S. Government.

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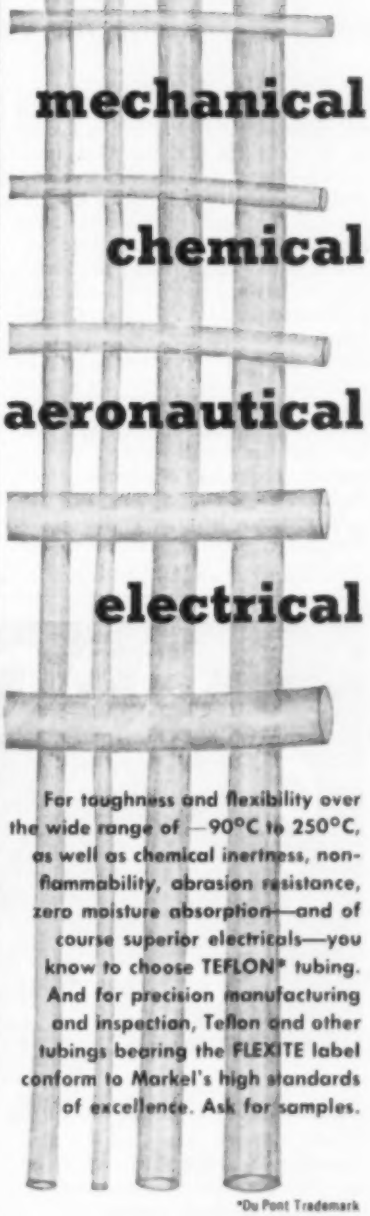

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local sections

McAfee defines chem engineer, A.I.Ch.E. role, at Oklahoma One-Day

Jerry McAfee with officers of the Oklahoma Local Sections in Tulsa. Occasion was the March 12 All-Day Meeting of the three Oklahoma Sections, held in Bartlesville. (L. to r.) V. L. Brant, Tulsa Section chairman; McAfee, E. W. Kilgren, general chairman for the upcoming Tulsa National Meeting; L. A. Warzel, Bartlesville Section chairman; and J. B. West, Central Oklahoma Section chairman.

WE LIVE IN A CHANGING world, and if we (chemical engineers) are to live up to our potentialities, we must grow and change continually to meet new challenges and new needs, Jerry McAfee told the **All-Day Oklahoma State Meeting** in Bartlesville. McAfee was the featured speaker at the March gathering, co-sponsored by all three Oklahoma Sections: **Tulsa, Central Oklahoma and Bartlesville.** We must assess the great responsibilities and opportunities which lie before us and our profession, the A.I.Ch.E. president went on. But we must also realize that the world doesn't revolve around chemical engineering and chemical engineers.

In giving a basic definition of the chemical engineering profession, McAfee said, it is possible to get about as many variations as there are people to ask. He particularly liked the following: A chemical engineer is a person who is professionally involved in the chemical conversion of nature's raw materials into useful products needed by mankind. The human element is especially important. Others are engaged in chemical processing and related areas, but the chemical engineer makes his contribution on a professional basis in the highest sense of the word.

Broadly speaking, the chemical engineer's unique field is the chemical transformation of materials into other more useful materials. He used the word useful, he said, because while we are concerned with laboratory developments, our scope is much broader than just laboratory work. Our job is not done until the conversion is accomplished on a truly useful, that is on a commercial or an industrial, scale. Finally, since the products of our efforts are for the benefit of mankind, our profession is dedicated to the service of our fellowman. McAfee continued by saying he thinks everyone will agree that the chemical

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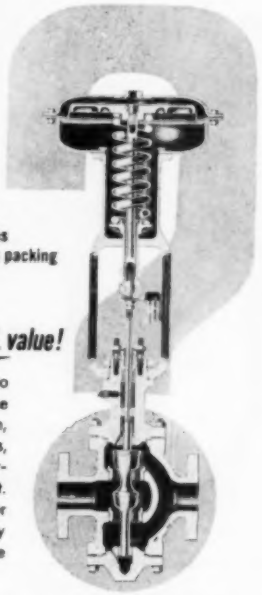

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engineer is pursuing a considerably more lofty objective than simply the conversion of raw materials, or making money, or applying scientific principles to commercial projects. The engineer is engaged in making this world a better place to live in, improving man's lot and advancing our civilization.

McAfee went on to discuss A.I.Ch.E. activities, and the part the organization plays as a voluntary association of individual chemical engineers in the advancement of chemical engineering theory and practice. The maintenance of a high professional standard among its members is perhaps one of its most important functions. The Institute's purpose from the beginning has been two-fold, taking in both technical and professional areas. The opportunity to meet together with other chemical engineers is one of the principal reasons for its existence. Certainly among the most important of all the opportunities to meet together are the meetings of the local sections, McAfee concluded, which he has always maintained, are the real backbone of the organization.

The 8-paper meeting, held in Bartlesville, covered a wide variety of subjects. *Legal implications of foreign Investments*, Lloyd G. Minter, led off. J. P. McCullough brought the gathering up to date on *Progress in the Thermodynamics of Petroleum Constituents and Petrochemicals*. Other papers presented were *Film Penetration, Model Predictions of Eddy Diffusivities in Low Level Turbulence; Technical Requirements of Hydrocarbon Rocket Fuels*, G. D. Kittredge, and *Synthetic Rubber, Its Properties and Uses*, R. S. Hanmer.

A panel discussion on experiences in foreign assignments wound up the meeting. L. W. Pollock was program chairman for the All-Day gathering.

Sabine Area All-Day confab

The Seventh Annual All-Day Meeting of the **Sabine Area Section** (*William Jaggers*) covered developments in both chemical engineering and chemistry, and the question of computer control. Two simultaneous morning sessions were divided between chemistry and chemical engineering. The afternoon was given over to computer control. Toastmaster at the evening banquet was John E. Grey, president of the First National Bank in Beaumont. Featured speaker was Arthur A. Smith, economist and vice president, First National Bank in

continued on page 164

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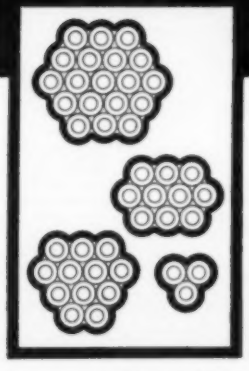

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local sections

from page 163

Dallas, who talked on the *State of Taxes in Texas*. The meeting was co-sponsored by the Texas-Louisiana Gulf Section of ACS.

Manpower problems

College science programs should be generalized, specialized only in the last year, Sidney Steele told the **Maryland Section** (*J. W. Holtz*) in March. Steele, an Atlas Powder public relations man, feels that some students steer away from the scientific field because they have not yet decided specifically what they want. If the necessity to select a specialty early in the college program were eliminated, this problem would be solved. This would encourage enrollment of students with a high science aptitude.

Andrew W. Shearer, Atlas, also feels that the quality of scientific manpower has been adversely affected by the increased specialization trend. He told the **Philadelphia-Wilmington Section** (*Donald J. Smith*) that this trend toward specialization, particularly at too early a stage in educational development, cuts down the potential engineering personnel, and therefore their contribution. A decline in scholarship has set in, which starts with a watering down of curricula and standards. This is especially so in public high schools.

While the total number of students enrolled in colleges last year reached a new peak, more than 200,000 students each year in the top 25-30 percent of the high school class drop out before graduation, or fail to go on to college. This shocking waste of the talents of American young people must stop, Shearer said. If some of these students could be encouraged and supported to continue higher education, engineering would receive its proper share. The important thing is not to pressure someone into the field who has little aptitude for it, but to encourage students with real potential by offering them a good science curriculum.

Springtime in the Rockies

The **Rocky Mountain Section** (*A. L. Benham*) February and March meetings were devoted to computers. Purpose: an understanding of the differences between analog and digital computers, and the uses to which each can be put, both for process control and for the solution of engineering problems. George Miller, research physicist for Ohio Oil Company, spoke to the first meeting on analogs, particularly the general purpose analog. Digital computers were R. Curtis Johnson's topic at the second meeting. Johnson is with the process analysis department, Thompson-Ramo-Wooldridge.

On the New Section front

Fairfield County Chemical Engineering Society has been chartered as a local section. The 72nd local group to affiliate with the national organization, the society was formed over a year ago to serve the needs of chemical engineers living in the Greenwich, Fairfield and Danbury areas. First meeting of the new **Fairfield County Section** was held jointly with the **New Haven Section** in March. V. V. Lindgren talked on his recent trip to the Soviet Union, and his observations on the plastics industry there. Lindgren is technical director, Plastics and Resins Division, American Cyanamid.

Also Meeting

Ladies' Night at the **Detroit Section** (*W. Leisten*) in March featured C. B. Leonhard, trust consultant, on wills and estate planning . . . Modern sci-

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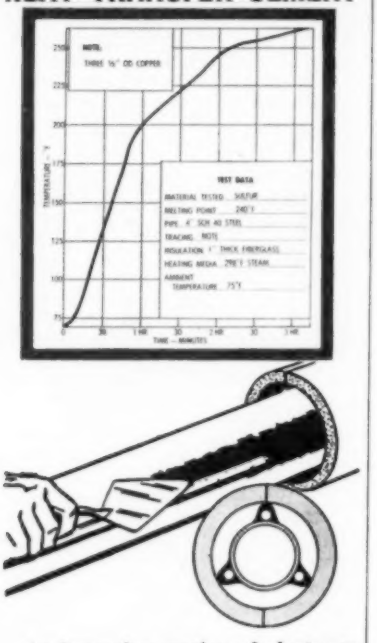

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local sections

continued

ence and anthropology was Robert Vines' talk topic at **South Texas Section** (*G. H. Cummings*) in March. Vines is Science Supervisor, Spring Branch Independent School District . . . Government services and the New Jersey tax system were discussed at the **New Jersey Section** in February. The speaker was Bennett M. Rich, director, Bureau of Government Research . . . Glass ceramics: a review of the general principles of nucleation and growth of crystals, and a discussion of crystallization in glass in the light of these principles. This was the January **Rochester Section** (*Robert L. Kramer*) meeting. S. D. Stookey, manager, fundamental chemical research, Corning Glass Works, was the speaker . . . New developments in fuel cells were outlined by Herman A. Leibhafsky, GE, to members of the **Boston Section** (*R. L. Wentworth*) in February. The Ichthylogists met jointly with ACS . . . A quick survey of Russian educational facilities, was on the agenda at the **Charleston Section** (*G. O. Walker*) in January. L. K. Lovenstein, the speaker, recently returned from the Soviet Union. The superintendent of Kanawha County Schools, Lovenstein's trip was as part of a group sponsored by the American Association of School Administration . . . R. B. Fix, of Weisenbaker, Fix and Associates, spoke on the use of pre-stressed concrete for storage tanks. Occasion was the **East Texas Section** meeting (*J. M. Dauphin*) in January . . . The **Western Massachusetts Section** (*V. A. Aliberti*) heard John Magee, stock counsellor, on Wall Street and current stock trends, in March . . . A number of guest students sat in on the **Southwest Louisiana Section** (*Robert L. Goodkind*) in March. Talk was on rockets, guided missiles and space travels.

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Objections to the election of any of these candidates from Members and Associate Members will receive careful consideration if received before June 15, 1960, at the office of the Secretary, A.I.Ch.E., 25 West 45th Street, New York 36, N. Y.

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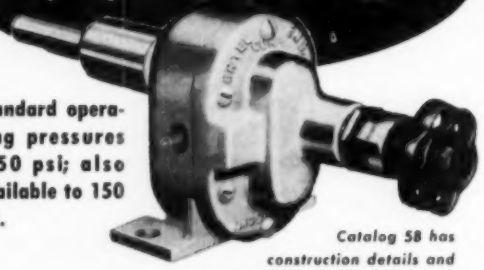

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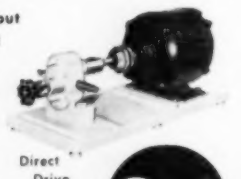

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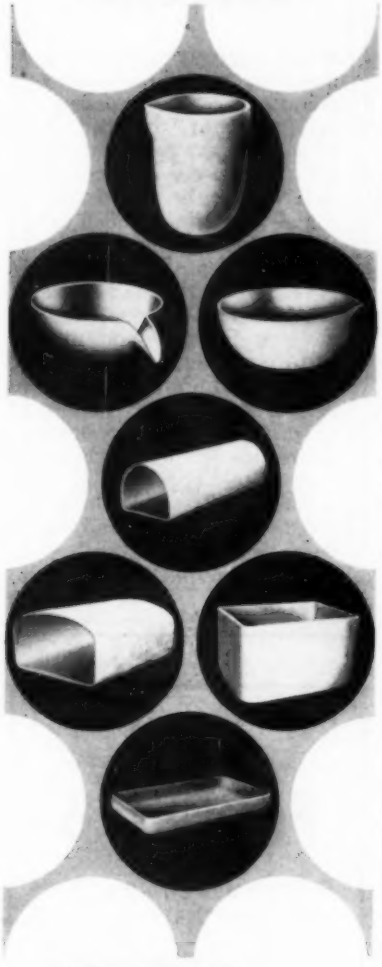

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industrial news

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Special course on systems engineering, and advanced computer techniques will be held at a three week summer conference for chemical engineering teachers at Washington University in St. Louis, June 7-30.

CHEMICAL ENGINEERING TEACHERS will get an opportunity to bone up on systems engineering theory and practice at a special summer conference. About thirty instructors will be selected to attend the three week program at Washington University, St. Louis, Missouri, June 7-30. Sponsored by A.I.Ch.E. through its process control committee, and the Foundation for Instrumentation Education and Research (FIER), the classes are made possible by a grant from the National Science Foundation. They are patterned after a similar conference held last year at Case Institute.

A briefing on the most advanced computer techniques and practical applications of theory highlight the course. A concentrated review of advanced mathematical and analytical techniques of systems engineering as applied to chemical processes will also be studied. A week of the period will be spent at the Monsanto Chemical Company, in St. Louis, where one of the largest analog computers in the process industry, as well as the chemical industry's only IBM 704, are available. So teachers can work on programming and use where actual industrial problems are now under attack. This opportunity to work on practical applications of systems engineering theory is considered invaluable in helping to advance training methods in the universities on systems engineering.

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(continued on page 174)

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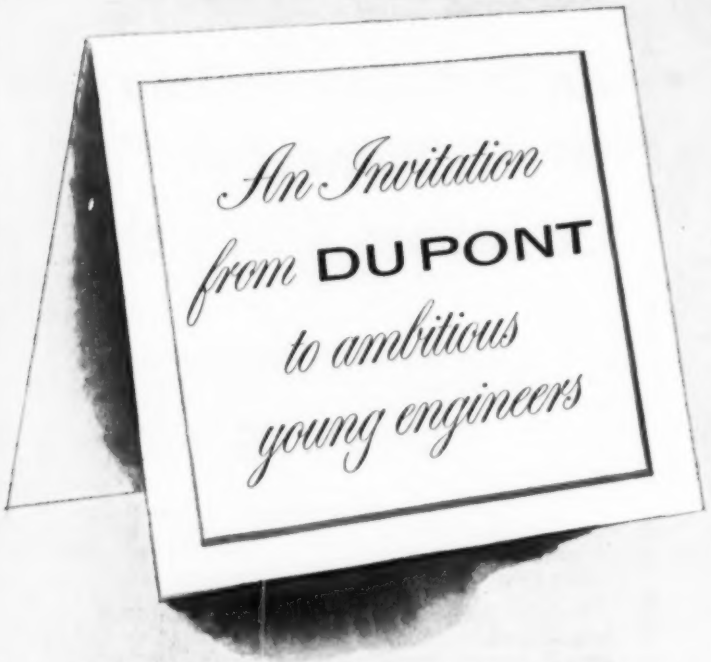

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PROJECT ENGINEER for a new division of a chemical company, graduate chemical, with five to six years' experience as project engineer or estimating engineer. Experience in engineering department of chemical company and knowledge of chemical plant equipment desirable. Salary, $5400-$9600 a year. Location, New York, N. Y. W-8831.

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DEVELOPMENT ENGINEERS, graduate chemical, with experience in machine design, coating and drying or process control systems desirable but not essential. Work will involve process development engineering and application in chemical and mechanical operations. Location, northern New Jersey. W-8774.

CHEMICAL ENGINEERS. (a) Chemical Engineer, graduate, with at least five years' experience in pilot plant development and process design. Should be strong in the understanding and use of engineering fundamentals while showing successful record of experimental and/or development work. Salary, $7500-$10,000 a year. (b) Chemical Engineer, graduate, with three to eight years' experience in process and economic evaluation, with strong background in thermodynamics, heat and mass transfer and unit operations. Salary, $7-$10,000 a year. (c) Junior Chemical Engineer, graduate, for design and pilot plant operations. Salary, $6-$7500 a year. Location, New Jersey Metropolitan area. W-8758.

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Chicago Office

PROCESS ENGINEER, chemical Engineering degree; two years' experience in process design in one or more of the following: gas treating, petro-chemicals, natural gasoline plant design. Have good background in unit operations and thermodynamics. Duties are to prepare heat and material balances around process units, write specifications for process equipment, design fractionating towers, absorbers, bubble trays, etc. Draw process flow sheets indicating major items of process equipment and major instrumentation. Salary to $10,000 a year. Location, Missouri. C-8030(a).

San Francisco Office

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ASSISTANT ENGINEER, preferably graduate chemical or mechanical, with two years' responsible engineering experience, or a minimum of one year process control experience in chemical, petroleum, gas or power industries. Operation of equipment, calculations and related work in source test division, under minimum supervision. Specialized job training given. Salary, $6600-$8000 a year. Location, San Francisco Bay area. SJ-5176.

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PROCESS CHEMICAL ENGINEER, recent graduate or potential graduate, for product development and research activities. Salaries open. Apply by resume and academic record. Location, southern California. SJ-5094(b).

DESIGNERS (a) Designers, chemical or mechanical graduates, experienced in design of refineries, petroleum, petro-chemical plants. Will work with project group in carrying out engineering work related to design plans, specifications and construction. (b) Designers, chemical graduates, well experienced in designing process plants from flow sheet and other related data. Salary, about $10,000-$15,000 a year. Location, San Francisco. SJ-5093.

ASSISTANT PLANT ENGINEER, chemical engineer, to 30, recent graduate with one to two years' working experience; should be able to assist plant engineer in normal plant maintenance, construction and expansion. Will do some record keeping, supplies control, maintenance cost; ultimately requisition and purchase supplies. Some board work. For a chemical specialty process plant. Salary, $5700-$6300 a year. Location, San Francisco Bay area. SJ-5089.

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1—Stokes SS jacketed rotary vacuum dryer, 2' x 6'
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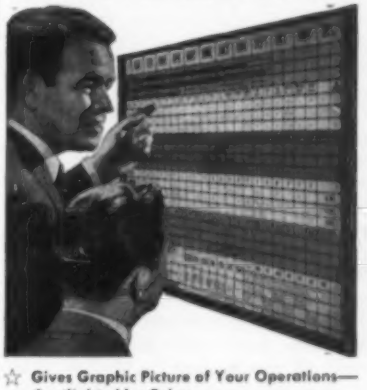

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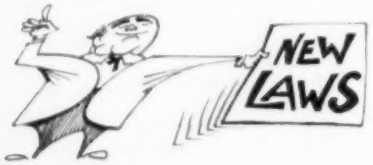
News and Notes of A.I.Ch.E.

Miscellany—At the Atlanta Meeting Charlie Swartout, the new Public Relations Chairman, characterized the Public Relations Committee as an "Admirable Hornblower." . . . Some member with a better knowledge of Greek than ours ripped out the February NEWS AND NOTES, circled the word **kudo** and wrote, "The word is kudos, which despite the 's' is singular like cosmos." To our unidentified correspondent, many thanks and our apologies. . . . On December first last year the Nuclear Engineering Division of A.I.Ch.E. had 582 members. . . . Walton Rodger, chairman of the division, was asked by Council through its liaison, Ray Genereaux, whether or not this group would be willing to undertake the responsibility for standards in the nuclear field for A.I.Ch.E. . . . Rodger and the Executive Committee of the Nuclear Division agreed and recently sent out an appeal to all members of the division for volunteers to work on nuclear standards . . . The A.I.Ch.E., as members know, is responsible for the N-5 section A of the American Standards Association. The response to the appeal for volunteers was gratifying . . . a number of real experts will be supplementing the efforts of A.I.Ch.E. in this field . . . Also the NED has prepared a speakers' list, which will be sent soon to the program chairmen and officers of all Local Sections, giving the names, addresses, and topics of men in the nuclear field who are available for talks before a Local Section . . . Rodger has one more reminder to Local Section officers: the Nuclear Division would like a representative from each Local Section; send all nominations to Walt Rodger at Argonne National Laboratory, 285 Lemont, Illinois.

The Professional Legislation Committee of A.I.Ch.E. is currently issu-



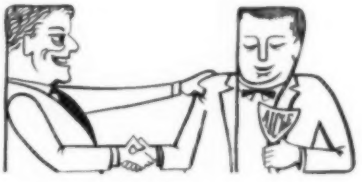
ing bulletins on legislation in the various states. Blaine Kuist, Chairman, is the editor. . . .

The Central Ohio Section invited all chemical engineering students attending Ohio State University to a meeting at which the section paid for the students' dinners. Bill Ellis of this section sent me last year the directory of the section, which has on its cover a detailed map of the area. In the Foreword Bill writes, "The section owes much to Joe Koffolt, and we would point especially to the excerpt from the press release of February 26, 1959." This referred to Joe's being named the Technical Man of the Year by the Columbus Technical Council. The directory gives a lot of information about the section, including statistics on its growth, the past and present officers, charter members, section high lights, and an alphabetical membership roll. . . . The Chemical Engineering Education Projects Committee has issued its first edition of a handbook on the committee's work. M. W. Bredekamp is Chairman. . . . Admiral Hussey, Managing Director of the American Standards Association, reported to the A.I.Ch.E. that in 1959 two hundred and eleven new and revised American standards were approved by member groups, of which A.I.Ch.E. is one.

The New York Section is working with the Technical Societies Council of New York in assisting the City Board of Education to conduct a guidance course for junior and senior high school guidance counselors. . . . The Charleston Section of A.I.Ch.E. has a joint scholarship fund with the local A.C.S. . . . Information sent out by the University of California on a salary survey of 1959 technical graduates indicates that chemical engineers—once top men on the totem pole as far as starting salaries are concerned—are now taking a back seat, with only civil engineers behind them. Electrical engineering graduates had the highest salaries, with a median of $545 compared with $500 for the chemical engineers.

The South Charleston Section recently quizzed its membership on the kind of meeting it wanted for the local group. In addition to asking how many meetings the member attended, the questioners tried to pin reasons for nonattendance down to such items as lack of parking facilities, kind of liquid refreshment served (beer or soft drinks), and type technical program offered.

Membership Drive—A number of sections are holding special membership nights this year. In charge of the membership night at various Local Sections are Robert L. Koffler and A. W. Taff, who are running the show at the Baltimore Section; George J. Keller—Southern California Section; B. F. Judson—Columbia Valley Section; G. H. Goff—Northern California Section; V. L. Brant—Tulsa Section; Victor Kalcevic — Midland Section; J. C. Eargle, Jr.—Savannah River Section; R. J. Bechtel—New Jersey Section; John J. Wheeler—Rochester Section; J. G. Brown—Detroit Section; and H. B. Morrison—St. Louis Section. Irv Leibson, Chairman of the Membership Committee for 1960, is



striving to organize each Local Section for a membership campaign; he is trying to do it along company lines. Irv has his eye on breaking all membership records in the A.I.Ch.E., and from the way the year has started he has a splendid chance to do this.

Council Actions. C. A. Stokes, former Director, submitted a report from a special committee to consider services to members. The report was received with thanks to the committee, and Council will now begin to study means of implementing the several suggestions made by the group. One immediately acceptable recommendation was that the President of the A.I.Ch.E. send out a letter to the membership three or four times a year covering essentially important points of Institute policy and decisions. . . . H. F. Nolting of the Standard Oil Company of Indiana agreed to accept the responsibility for preparing copy for the 1960 A.I.Ch.E. Annual Report. . . . Three new Local Sections were welcomed into the Institute: Lehigh Valley Section with headquarters at Bethlehem, Pennsylvania; the Fairfield County Section with headquarters at Stamford, Connecticut; and the Wisconsin Section with headquarters at Milwaukee, Wisconsin. . . . The Tennessee Valley Section asked that its name be changed to the North Alabama Section, a change that was speedily granted by Council.

F.J.V.A.

how to meter acids accurately against pressure

CORROSIVE liquids present two major obstacles to achieving maximum metering accuracy, economy, and safety. For one thing, corrosion can introduce an intolerable ever-changing volumetric error. For another, leakage can endanger personnel and necessitate the premature replacement of pump parts and associated equipment.

But both obstacles can be successfully overcome. First by choosing the right pump for the metering job at hand. Second, by making sure that all wetted parts of the pump chosen are inert to the liquid being metered. Here are some ideas based on practical acid metering experience that may help you to choose the best controlled volume pump for your metering needs.

Packed Plunger Pumps

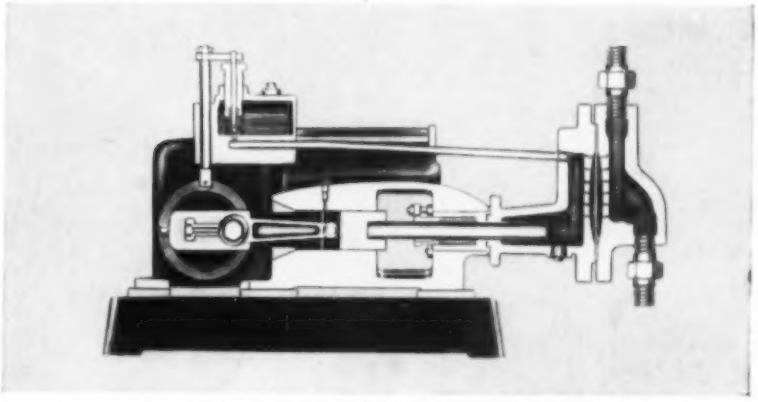
For the majority of mildly corrosive liquids, low cost packed plunger pumps have proved themselves entirely adequate. Some thirteen materials of construction are *standard* on packed plunger pumps, running from cast iron to Hastelloy B and C, more than enough to satisfy mild corrosive metering requirements. Capacities to 2056 gph, pressures up to 50,000 psi.

An added tip: Standard Milton Roy motor driven pumps in corrosive service can be equipped with "catch-all" yoke type gland followers.

Diaphragm Liquid Ends

When the liquid to be metered is highly corrosive or otherwise dangerous, a controlled volume pump with diaphragm liquid end is the best choice. A plastic or stainless steel diaphragm positively separates the process liquid and the plunger. The plunger displaces a hydraulic fluid which in turn strokes the diaphragm to create pumping action through the ball checks. Consistently high accuracy is achieved through unique design features. As the illustration shows, positive mechanical action bleeds any air or vapor from the hydraulic side between strokes and corrects liquid volume if necessary. Internal liquid end design also automatically eliminates bubbles from the process liquid side.

Very often, a pump chosen for mild corrosive service is obsoleted by a process change specifying a more highly corrosive liquid. The diaphragm liquid end illustrated can easily be substituted for the conventional liquid end on any standard motor driven controlled volume pump, bringing the entire metering system up to date at little extra expense. *Designs of this type will handle up to 400 gph against heads to 2700 psi.*



Controlled Volume Pump With Diaphragm Liquid End

Totally Immersed Liquid Ends

Acids with high vapor pressure or high specific gravity require the Mersemetric® controlled volume pump. Pump drive and motor are mounted on the tank top, but the liquid end is completely submerged to a depth of up to fourteen feet. This same design feature also eliminates the need for tank connections below liquid level, and permits chemicals to be metered *directly* from storage.

The maximum safety - minimum handling Mersemetric design is just about standard for metering sulfuric acid for demineralizer regeneration and pH control of cooling tower water and deaerator effluents. *Capacities up to 218 gph, pressures up to 1200 psi.*

The Acid Metering System

You can be fairly sure of making the right choice only if you consider *all* the factors. Here are several points that are often overlooked:

- Is the entire *system* corrosion-resistant . . . storage tank, suction and discharge piping, controlled volume pump, and relief valve?
- Thoroughly consider the physical properties of the liquid. High vapor pressure or high specific gravity liquids may demand a suction head.
- Consider plant and personnel safety under all possible conditions.
- Consider maintenance as well as first cost in determining the economics of the system.

If precision pumping of dangerous chemicals is one of your problems, look again to Milton Roy's 25 years of experience for your most economical solution. Write for a general introduction to controlled volume pumping in Bulletin 553-1. Milton Roy Company, 1300 East Mermaid Lane, Phila. 18, Pa.

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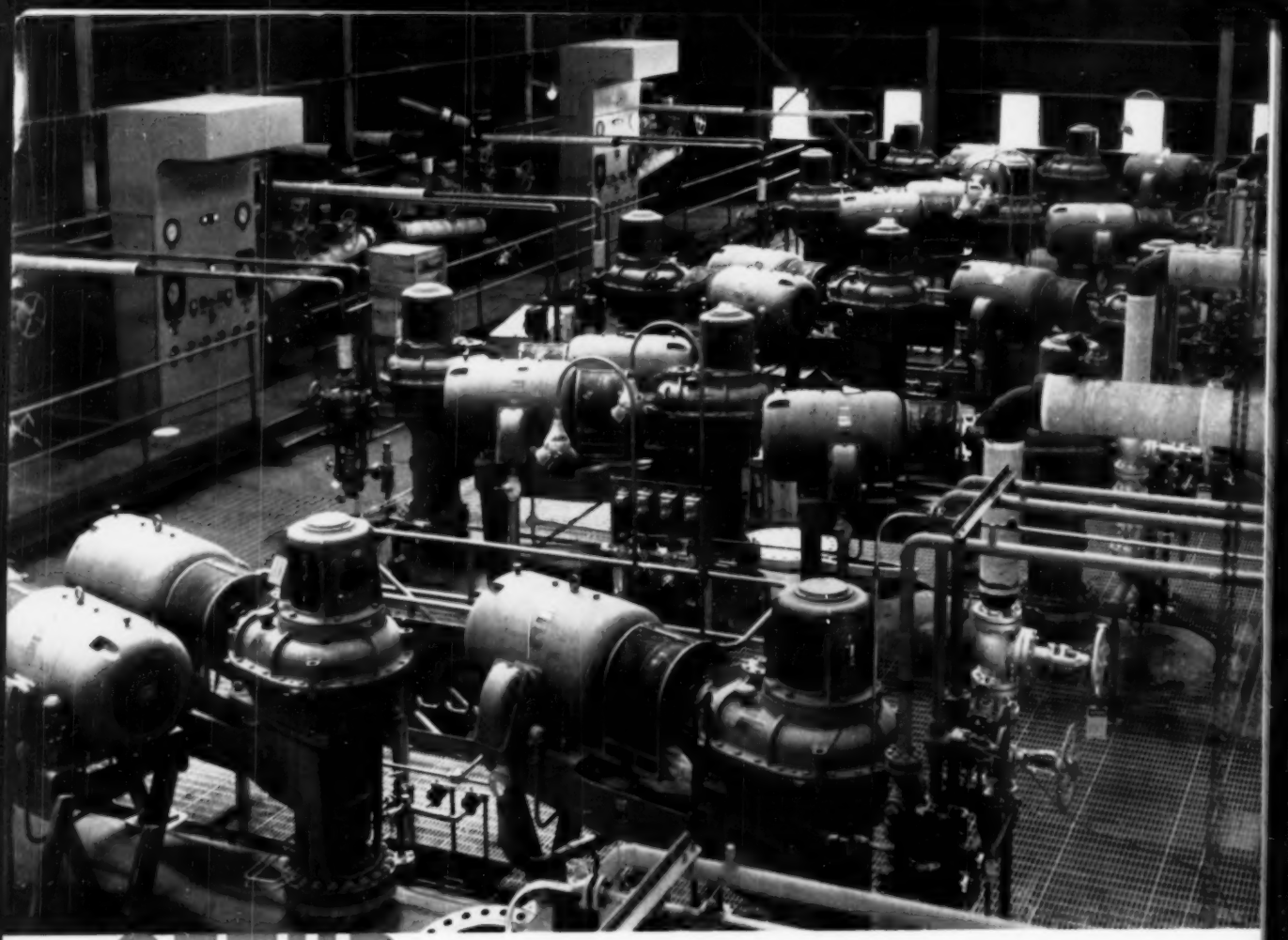

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As hydrogen hisses into the six autoclaves, 18 big dual-turbine impellers grip the heavy slurry and expose every ounce of it to the gas. As pure nickel forms, the mixers keep it suspended uniformly to seed the reaction. New charges of pregnant liquor flow in, and the densification process begins anew.

Each time a mixer starts, it may start with its lower impeller buried in settled nickel solids that throw a load of 300% of normal full torque upon the 125-hp mixer drive. A fluid coupling between motor and drive, and the distinctive hollow-quill design which is standard on Series E LIGHTNIN Mixers, insure that the shock never reaches the mixer drive gears.

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Engineers at Freeport Nickel *knew* what their mixing results would be long before they approved these mixers. MIXCO engineers lived with the project for months, checked power requirements by scientific methods, and demonstrated mixing results accurately in scale-model equipment.

If you'd like to take the guesswork and the risk out of fluid mixing on *your* next project, large or small, call in your LIGHTNIN Mixer representative. He's listed in Chemical Engineering Catalog and in the yellow pages of your phone directory. Or write us direct.

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